YEAST AS A SUPPLEMENTARY FEED FOR CALVES

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The importance of vitamins to human and animal nutrition is generally accepted. It is not so clear, however, as to the extent to which generalization based upon observation with one species can be applied to another. The rat and the prairie dog for example appear able to thrive without the antiscorbutic factor, or have the power of producing the substance synthetically within the body. The guinea pig on the other hand is very sensitive to a lack of this vitamin.

For this reason the question arises as to the extent to which results with laboratory animals can be applied to the larger domestic animals. So far investigations concerning the vitamin requirements of the larger domestic animals are exceedingly limited and it would appear a considerable proportion of those which have been reported may in addition have involved questions of mineral metabolism and a possible deficiency of some mineral elements.

Swine among domestic animals have received the greater amount of attention. The results with this species are somewhat conflicting but do not on the whole indicate any serious dangers from a deficiency of vitamins under practical conditions. Morrison and associates (1) have shown that yellow corn is superior to white corn for swine when no other source of vitamin A is present. On the other hand Orr and Chrichton (2) in a more recent report indicate no effects were apparent from feeding pigs for a period of 110 days on rations essentially free from either vitamin A or vitamin B.

The experimental data available regarding the relation of vitamins to the nutrition of cattle center around the question of the relation of the antirachitic factor to the assimilation of calcium and the disease known as lamziekte prevalent in South Africa.

Hart, Steenbock and associates (3) have made an important contribtuion indicating a relation between a fat soluble vitamin and the assimilation of calcium by the lactating cow.

The work of Theiler and associates (4) indicates that the disease known as lamziekte is the result of a toxin somewhat similar to the botulinus toxin and which is formed by organisms growing in the bones of dead cattle. As a result of a serious mineral deficiency of the cattle due in turn to a soil low in minerals, the animals develop "pica" or abnormal appetite and eat bones and other parts of the carcasses of dead animals containing this toxin.

This disease is of interest here on account of the fact that while it was under investigation prolonged tests of rations low in vitamin were made with cattle. Cattle were kept for a year on a ration consisting chiefly of white rice with no evidence of beri-beri symptoms. Extracts rich in vitamin B were also fed without any effect. One cow fed white rice and autoclaved straw gave birth to a blind calf. Theiler suggested that the ability of the animal to survive without vitamin B in the ration might be due to the formation of the vitamin in the digestive tract as the result of a bacterial symbiosis.

Significant data pointing towards this possibility have been published recently. Damon (5) found that the addition to the ration of desiccated preparations of certain bacteria including B. timothy (the timothy grass bacillus of Moeller) served to supply the vitamin needed for the growth of rats. Scheunert and Schierlich (6) report that B. vulgatus (Flügge) Migula, an organism which grows rapidly in the intestines of herbivora, is able to synthesize vitamin B in a vitamin free medium Pigeons were used in making these tests.

Another point to be considered is that the ration as received by cattle under ordinary conditions is mixed in character, including usually ground seeds and especially a large amount of roughage.

Considering the nature of the ration the danger of a deficiency of vitamins in the nutrition of the bovine would appear remote. However, the present tendency is towards the feeding of more by-products, especially of the milling industry, and this increases the possibility of such a shortage occurring.

Pronounced effects have been reported from feeding vitamin B in the form of yeast to laboratory animals. Hawk and others have also reported improved health in humans following the administration of yeast. These results suggest the possibility that yeast might have some value as a supplementary feed for calves.

The large quantities of spent yeast, a brewery by-product available from breweries, presents an opportunity for increased profits by finding a suitable means of disposal and has lead to a considerable amount of experimental work. The use of this by-product as a feed for livestock appeared to be the best solution and for a number of years the use of spent yeast as a feed for farm animals, especially cattle, has been common. Among those contributing to the development of methods of preserving this by-product were Schmidt (7), Makin (8), Hayduck (9), Fallada (10), Herzfield (11), and Miller (12).

The variety of methods followed in the preparation of this material for feeding purposes naturally results in a wide range in the composition of the product as used for feeding purposes. Czadek (13) gives the following analysis and digestion coefficients for a yeast feed used in his experiments.

	PER CENT	DIGESTION COEFFICIENT
Moisture	10.90	
Protein	55.60	90.8
Ether extract	0.53	62.5
Nitrogen free extract	18.90	76.4
Fiber	5.85	
Ash	8.31	

It should be pointed out that spent yeast as used for feeding purposes in Europe has been generally considered as a source of protein and energy as would be the case with other more common

feeds and not on account of any special dietetic or nutritional value. The experiments reported show in general that dried spent yeast is a suitable feed for cattle and is the source of a highly digestible protein supplement.

RELATION OF VITAMIN B TO GROWTH

Vitamin B is often referred to as a "growth promoting vitamin or accessory" and the necessity of this vitamin for the growth of experimental animals is now generally accepted.

Sherman and Smith (14) after reviewing the whole field of investigations with vitamin B state that the absence of B from the diet causes cessation of growth; that a partial but not complete deficiency in this vitamin leads to impaired growth and a general undermining of health and vigor and this lowered vitality may have a far reaching effect in its influence on reproduction and the successful rearing of young.

Experimental

The fundamental principles of nutrition can unquestionably be studied to the best advantage by the use of small laboratory animals. There is, however, an uncertainty as to what extent these results may be applied to the larger species of domestic animals. With the vast economic importance of the larger domestic animals it becomes a matter of great concern to determine to what extent the findings from the small animals apply and especially if the practice of feeding as now followed results in serious economic losses.

It would appear to be the function of the agricultural experiment stations to make these applications suggested. With this object in mind investigations have been undertaken for the purpose of studying one phase of this subject, that of the relation of vitamins to the growth of calves. In planning these studies the logical procedure appeared to be: (a) to determine if the growing calf requires the same vitamins as has been found necessary for the growth of laboratory animals; (b) an estimation of the quantitative requirements in terms of some feedstuff serving as an espe-

cially potent source of the vitamin in question; (c) to determine if there is any danger of rations as ordinarily used in practice being deficient in the vitamin in question; (d) if there is any advantage in giving a surplus of the vitamin.

The first to receive our attention was the B vitamin. This vitamin was selected for study on account of the fact that yeast, a potent source of vitamin B, is available in large quantities as a by-product from breweries and yeast factories. Moreover the work of Hawk and associates (15) has aroused a wide spread interest in the use of yeast in the human dietary and attempts are being made to introduce yeast products as supplementary animal feeds. Furthermore assistance in financing the investigation was available from a commercial organization interested in yeast products. The logical procedure would be to develop the study in the order suggested in a previous paragraph. The opportunity to secure finanical aid, however, made it advisable to first determine if any advantages could be found from the addition of yeast as a supplementary feed to rations such as are commonly used in practice. If beneficial results are possible from yeast feeding it seems safe to assume that the growing calf and the cow in milk would profit most. For this reason our experiments included calves from birth to six months of age and lactating cows. The results from the latter will be reported in a later paper.

While milk is not generally looked upon as an especially good source of vitamin B the fact is that on the dry matter basis it is perhaps in the same class as seeds and can be looked upon as a good source of this vitamin. It has been demonstrated that the amount of vitamin B present in milk is dependent upon the amount supplied with the ration and consequently varies from time to time. Results from adding yeast to the ration of calves were expected to show a stimulation of the rate of growth, or in a more healthy condition of the animals.

Plan of experiment

The first series included nine calves divided into three groups and receiving rations as follows:

Group 1. Whole milk, grain and hay to 180 days. Limitations placed on grain and hay. Dried bakers' yeast fed intermittently during the period.

Group 6. Skimmilk to 60 days with addition of grain and hay. Dried bakers' yeast was added for prolonged periods up to 180 days.

Group 3. Skimmilk, grain and hay to 180 days. Dried brewers' yeast fed intermittently.

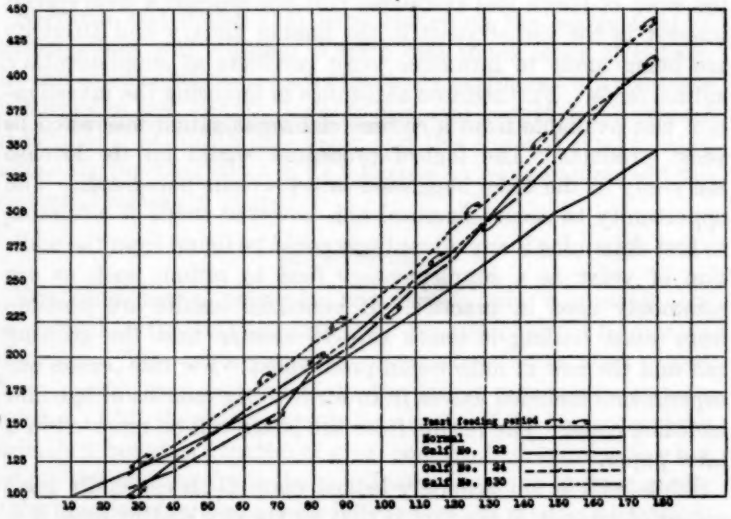

FIG. 1. THE RESULT OF ADDING YEAST TO A RATION INCLUDING WHOLE MILK

These three calves made a gain in weight above the normal as a result of the whole milk received. The yeast feeding, which is indicated by the arrows, did not make any noticeable increase in the rate of growth.

In arranging these groups it was planned that group 1 would represent conditions as found in purebred herds where the best ration is fed regardless of economy. Group 2 represented the plan of raising calves according to the "minimum milk" plan which has been under investigation by this experiment station for several years, and group 3 represented typical rations used when the raising of calves on skimmilk is practiced.

In this series the yeast used was of the kind sold as bakers' yeast. It was received in large lots and dried at a low temperature as a means of preservation. The air dried product contained about 50 per cent filler in the form of starch. It was fed in the dry form in quantities equal to 120 grams of fresh bakers' yeast daily to each experimental calf, a quantity three or four times the amount a human being might consume. The periods of yeast feeding are shown by arrows on figures 1 and 2.

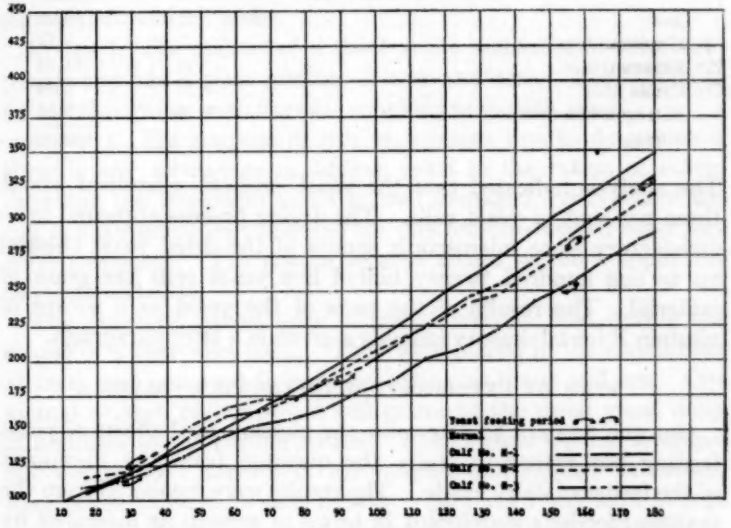

FIG. 2. THE RESULT OF ADDING YEAST TO A RATION FED CALVES WEANED AT SIXTY DAYS

These three calves received a ration including skimmilk to the age of 60 days, with grain and alfalfa after that age. The yeast was added during the intervals indicated by the arrows. The yeast feeding had no noticeable effect upon the rate of growth.

No appreciable effect could be seen on the appetite of the animals or the rate of growth. The calves, with the exception of one that contracted pneumonia and died, remained in excellent health and were perhaps more than usually vigorous.

Experiments with dried commerical yeast

The second series of experiments was conducted for the purpose of testing the value of commercial dry yeast as a supplement to the rations of growing calves. The yeast used is sold in large quantities in the dry form, the yeast cells being mixed with ground grains, apparently mostly cornmeal. The following is the chemical analysis of the yeast product used.

	per cent
Ash	10.60
Crude protein	1.75
Ether extract	11.65
Crude fiber	1.04
Nitrogen free extract	71.06
Total	100.00

The analysis indicated that the yeast product contained about three per cent of yeast cells. The drying process appeared to be satisfactory since microscopic counts of the dried yeast showed up to one hundred twenty billion live yeast cells per gram of material. The results of the tests of the yeast as a source of vitamin B for laboratory animals is given in a later paragraph.

PLAN OF EXPERIMENT WITH GROWING CALVES

Our aim was not to determine the physiological effects of yeast feeding but rather to study the question from the viewpoint of the feeder of dairy cattle. The results were measured from the practical feeder's standpoint in terms of growth as indicated by skeletal development, gain in weight, health as indicated by general appearances, and freedom from disease. The rations ordinarily fed calves in the better herds include such feed stuffs as legume hays, milk, corn, and cereal grains, substances which are good sources of vitamin B. If the requirements of cattle for this factor approximate those of laboratory animals in relaton to food intake there should be little danger of a deficiency occurring. If these assumptions are correct the experiments reported should indicate not the necessity of vitamin B in the ration but rather whether the addition of an extra amount of this vitamin in a potent source like yeast will have any favorable effect.

A total of 38 calves were used of which 18 served as check and 20 received the yeast supplement. Three groups were used with the general plan of feeding as follows:

Group 1. Yeast was added during the year to the rations of half the calves born in the University purebred dairy herd. These calves were otherwise raised in the ordinary manner.

Group 2. A second group composed of grade calves was fed skimmilk, alfalfa hay and grain mixture of corn, wheat, bran, and oilmeal. The rations received by part of these calves were supplemented with yeast.

Group 3. The rations of a third group consisted of skimmilk, prairie hay and a grain mixture of corn and oats. The rations of half of this group were likewise supplemented with yeast.

Group 1. The purpose of this experiment was to determine if there is any advantage in adding yeast to the ration of calves receiving the treatment usual in well managed herds where the calf has considerable value and for this reason received especially good treatment. The results secured would be most applicable to purebred herds.

The purebred calves born in the University herd during the course of a year were used. They were placed in the experiment at birth and arranged in pairs according to breed and sex. One animal of each pair received 100 grams of the dried yeast daily in addition to the regular ration. Eleven pairs were so arranged and compared. Records of the weights and heights at withers were taken three days each month. No record was kept of feed consumed, otherwise than of the amount of yeast. The herdsman was instructed to follow his usual routine except to add the yeast supplement to those designated. The results are shown in figure 3 in which the averages are given for the groups compared to the normal. It will be noted that those receiving the yeast made a slightly better growth during the latter half of the period. The check group finished 104.5 per cent normal in weight and 101.9 per cent in height. The yeast group at the close were 107.8 per cent normal in weight and 102.8 per cent in height. This difference is too small to be of any special significance.

Group 2. This group consisted of eight vigorous grade Holstein heifer calves purchased from a dealer and placed on experiment at about 20 days of age. Of these five were experimental and three controls. This group was to represent typical methods of feeding followed when calves are raised with skimmilk. The skimmilk was fed at the rate of 16 pounds daily with an allowance of

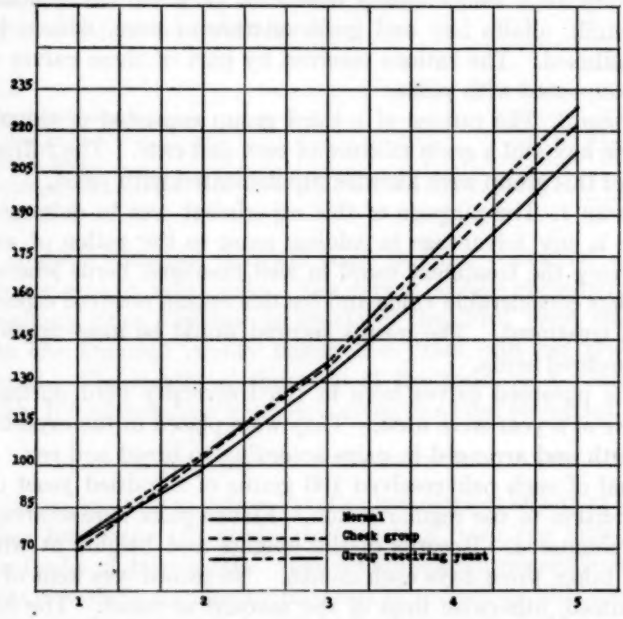

FIG. 3. THE RESULTS OF ADDING YEAST TO THE RATIONS OF CALVES FED OTHERWISE ACCORDING TO THE USUAL PRACTICE IN THE UNIVERSITY HERD

The line marked "check group" shows the average growth as shown by weight of eleven calves receiving the usual calf ration. The line marked "group receiving yeast" shows the average of eleven calves receiving the same ration with a supplement of 100 grams of dried yeast daily.

from 2.5 to 3 pounds of grain, and as much hay as would be consumed. Those receiving the yeast supplement were started at 50 grams daily which was gradually increased to as high as 300 grams. On account of the negative results it is not considered

necessary to give the data in detail. The results are shown graphically in figures 4 and 5 in which the growth of the check and experimental animals is compared to the normal. The results in percentage of the normal are given below.

	CHECK GROUP THREE ANIMALS	RECEIVING YEAST IN ADDITION, FOUR ANIMALS
Per cent of normal weight at beginning	104.6	107.6
Per cent normal weight at 180 days	110.6	103.2
Per cent normal height at beginning	100.4	102.3
Per cent normal height at 180 days	99.8	100.4

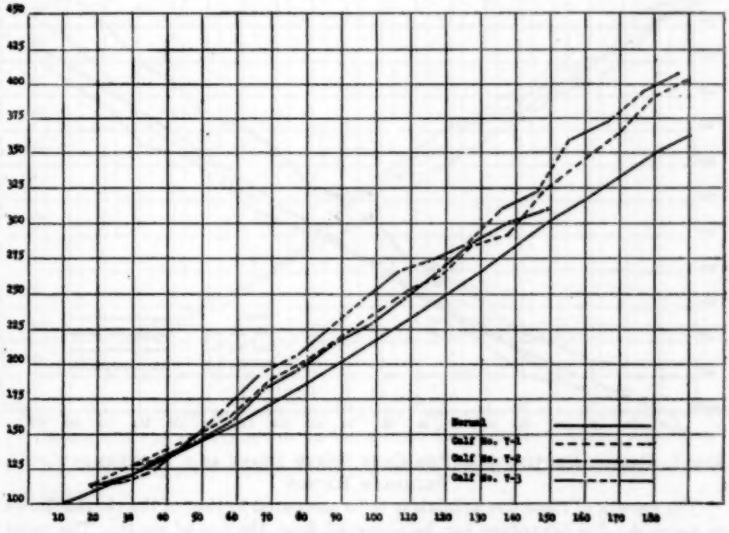

FIG. 4. CHECK GROUPS RECEIVING NORMAL SKIMMILK RATION

These three animals served as checks for those receiving the yeast supplement. The growth of the experimental animals receiving the same ration with a yeast supplement is shown in figure 5. It will be noted that the check animals gained in weight somewhat more rapidly than the normal.

Evidently the yeast did not stimulate the growth of these calves. In fact the check animals made the best growth. The results are considered negative.

Group 3. It was realized that the ration used in group 2 was a good one and one known to give normal results. Under conditions as existing on farms, a considerable proportion of the calves raised do not receive a ration as favorable from the standpoint of composition. For this reason it was decided that the third group should have a ration that would represent a rather inferior ration, but one that would be typical of feeding as often practiced. This ration was prairie hay, corn, and oats. This ration is inferior

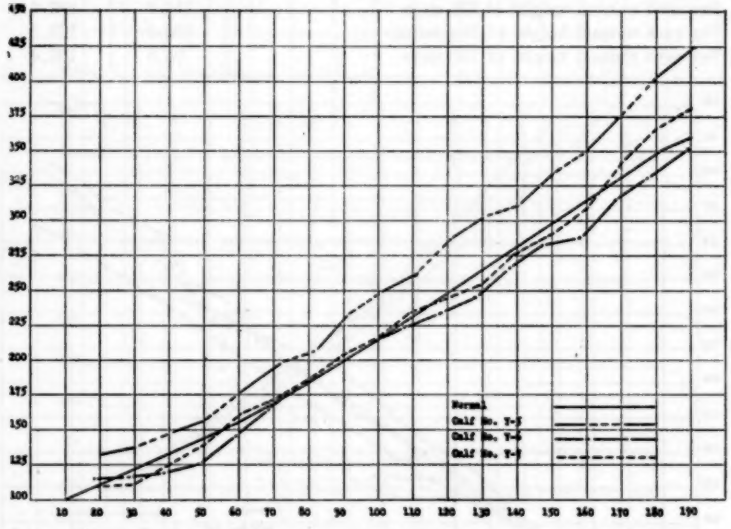

FIG. 5. CALVES RECEIVING 10 PER CENT DRIED YEAST AS A SUPPLEMENT TO A SKIMMILK RATION

The growth of these five animals is to be compared to that of the checks shown in figure 4. No advantage can be observed from the use of yeast. The gains made by the check group without the yeast were somewhat better.

to that used in group 2, in the amount and quality of proteins, in the calcium and phosphorous, and probably in vitamins. However, similar rations are widely used where leguminous hays are not grown and where such feeds as bran and linseed meal are considered too expensive.

The group consisted of eight vigorous Holstein heifer calves. Four were used as checks and four received the yeast supplement.

The skimmilk was fed at the rate of 16 pounds daily with from 1 to 3 pounds of mixed corn and oats and prairie hay at will, the amount consumed increasing from nothing up to about 4 pounds daily at six months of age. The four experimental animals received dry yeast in quantities to supply 10 per cent of the dry matter of the ration. The results are shown graphically in

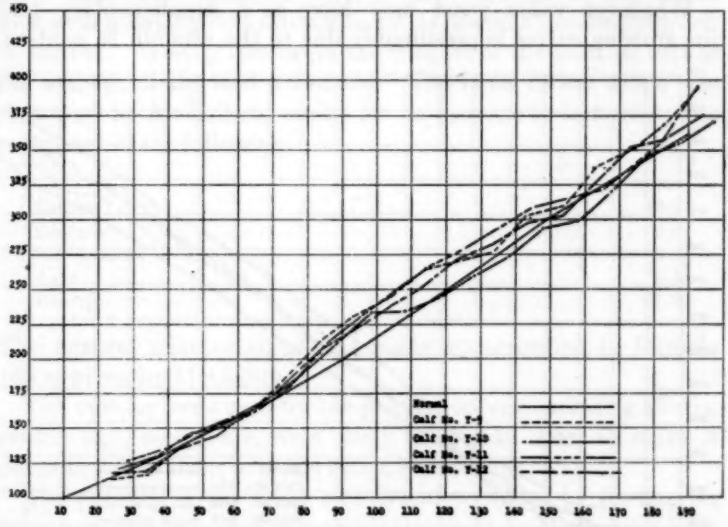

FIG. 6. THE GROWTH AS SHOWN BY WEIGHT COMPARED TO THE NORMAL OF FOUR CHECK CALVES IN A RATION OF SKIMMILK, PRAIRIE HAY, CORN AND OATS

The results from the experimental animals for which these are checks are shown in figure 7.

figures 6 and 7. The following figures show the comparative growth represented in percentages of the normal.

	CHECK GROUP, FOUR ANIMALS	RECEIVING YEAST IN ADDITION, FOUR ANIMALS
Per cent normal weight at beginning	103.3	105.5
Per cent normal weight at 6 months of age	104.3	108.4
Per cent normal height at beginning	98.7	100.0
Per cent normal height at 6 months of age	100.4	102.5

With this group those receiving the yeast supplement made a slightly better gain in both weight and height. However, the difference is not significant and not greater than the advantage shown in favor of the check animals in group 2.

LABORATORY TESTS OF THE YEAST FED

Whatever value yeast may have as a supplementary feed for growing calves is presumably due to the vitamin B. content.

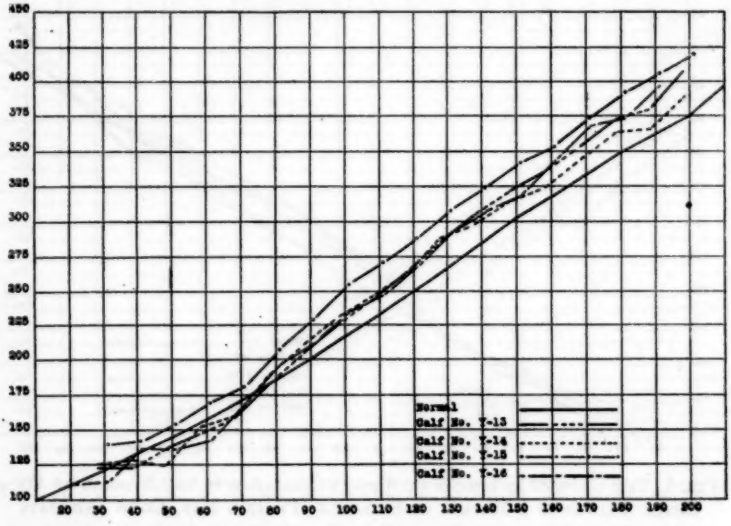

FIG. 7. THE GROWTH AS SHOWN BY WEIGHT COMPARED TO THE NORMAL OF FOUR CALVES RECEIVING THE SAME RATION AS THOSE SHOWN IN FIGURE 6, BUT WITH THE ADDITION OF DRIED YEAST EQUAL TO 10 PER CENT OF THE DRY MATTER IN THE RATION

The yeast did not appear to have any effect upon the growth of the calves

For this reason it appeared advisable to test the yeast used in the second series of experiments as a carrier of this vitamin by small animal experiments. The white rat was used for this purpose.

The specific objects of the small animal experiments were as follows:

1. To determine the level at which it was necessary to feed the commercial yeast preparation in the ration of rats as a sole source of vitamin B, in order to obtain normal growth.

2. To determine the influence, on the growth of rats, of additions of the yeast preparation to rations which were typical of a good and a poor calf ration.

The methods followed were typcial of those usually employed in work of this kind. The animals were kept in individual cages with a supply of the experimental ration before them at all times. Each cage was equipped with a false bottom of one-fourth inch with wire screen to obviate as far as possible the consumption of excreta. Weekly records of the weights of the animals and of the amount of the feed consumed. The basal ration which was that used by McCollum, except for an increase in butterfat, was composed of the following:

	percentage
Casein	18.0
Butterfat	9.0
Salt mixture	3.7
Agar	2.0
Dextrin	67.3

The mineral mixture given was made up according to formula 185 as given by McCollum.

The various feeds used for the growing calves, including alfalfa, prairie hay, corn, oats, were finely ground in order to make it possible to mix them with the ration successfully.

The potency of the yeast was first determined by feeding six groups of rats the dried commercial yeast at levels ranging from 10 to 40 per cent of the total ration. For some the yeast was substituted in the ration for an equal amount of dextrin, in other experiments the yeast preparation was fed separately. The results showed that a fairly satisfactory growth and reproduction resulted when commercial yeast was mixed with or fed separately in the ration to the extent of from 15 to 20 per cent. Typical results showing the growth curves of rats used are presented in figure 8.

The addition of the commercial dried yeast preparation to the ration of rats as a source of vitamin B resulted in good growth for more than a year and also enabled the rats to reproduce and and in some cases to rear their young. The use of higher levels

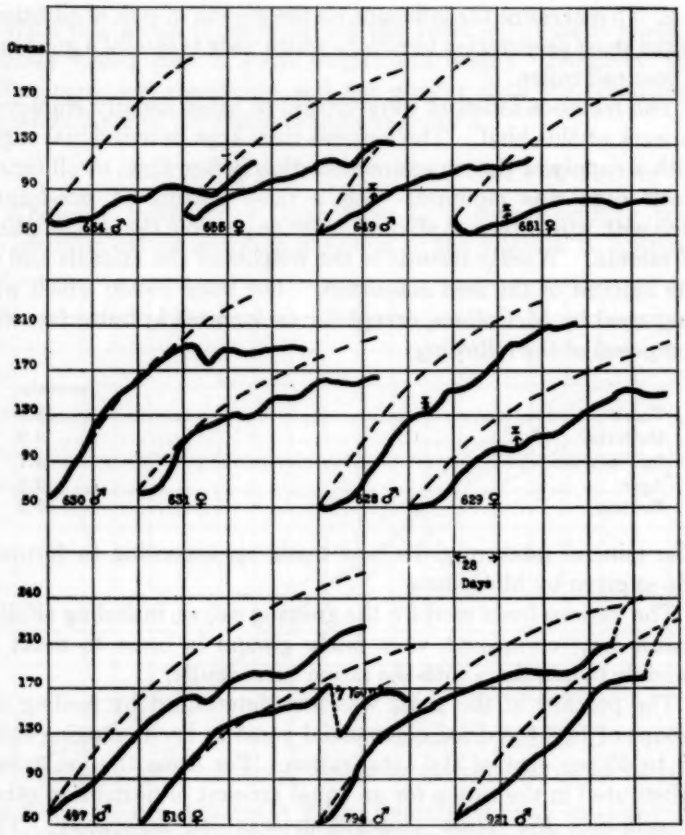

FIG. 8. GROWTH CURVES OF EXPERIMENTAL RATS

Rat 497 received a ration of casein, salts, butterfat, agar and corn starch dextrin containing 10 per cent of dry commercial yeast preparation.

Rat 510 received a like reaction containing 15 per cent of the yeast preparation. The litter of 7 young was successfully reared.

Rat 794 received the same basal ration without the yeast incorporated in it, and was given yeast separately at the rate of 10 per cent of the total food intake. The dotted part of the curve shows the effect of changing the ration to the one fed the breeding colony.

Rat 921, one of the litter of rat 510, was raised on the mother's diet. The dotted part of the growth curve shows the effect of changing the ration to that fed the breeding colony.

of this yeast up to 40 per cent of the ration did not induce any more favorable results. In no case was entirely normal growth obtained and when the ration was changed to one composed of cereal grains, legume seeds, alfalfa, cod liver oil, meat scraps, salts, and milk, the growth of the animals was stimulated and rapidly approached the normal. Several cases of polyneuritis resulted in nursing rats when their mothers received as high as 15 to 20 per cent of the yeast preparation.

Since the yeast preparation used is essentially a mixture of yeast cells and cornmeal it seemed worth while to also compare the yeast preparation with cornmeal as a source of vitamin B. It was found that the 15 per cent of ground yellow corn gave results somewhat inferior to 15 per cent of the dried yeast. Twenty-five per cent of white corn in the ration, as a source of vitamin B allowed rats to make practically normal growth.

Two groups of rats were fed the ration received by the calves in group 2. The ration as prepared for the feeding of the rats was composed of the following ingredients:

	per cent
Alfalfa	24.1
Cornmeal	31.54
Wheat bran	7.88
Oilmeal	7.88
Skimmilk powder	28.60

In addition one group of rats received ten grams of the dry yeast in each 100 grams of the ration. Both groups did well for a time, but finally began to fall behind the normal, due probably to the fact that the rat is not adapted to the utilization of a

Rats 630 and 631 received a diet consisting of alfalfa 24.0 parts, corn 31.5 parts, bran 7.9 parts, oil meal 7.9 parts, skimmilk powder (produced from the Station herd milk) 28.5 parts.

Rats 628 and 629 received the same diet as rats 630 and 631 except that 10 grams of the yeast preparation were added to 100 grams of ration. Beginning at x the yeast was fed separately at the rate of 1 gram daily.

Rats 654 and 655 received a diet consisting of prairie hay 24.1 parts, corn 23.6 parts, oats 23.7 parts, skimmilk powder 28.6 parts.

Rats 649 and 651 received the same diet as 654 and 655 except that 10 grams of the yeast preparation were added to 100 grams of ration. Beginning at x the yeast was fed separately at the rate of 1 gram daily.

ration containing so much bulk. No beneficial result was observed from the yeast. Typical results are shown in figure 8 for rats 630 and 631, which received the ration without yeast and for rats 628 and 269, which received the yeast addition.

The poorer ration fed the calves in group 3 was in like manner tested by feeding two groups of rats a ration essentially the same. The rations as received by the rats was composed of the following:

	per cent
Prairie hay	24.1
Cornmeal	23.65
Oats	23.65
Skimmilk powder	28.6

The ration received by one group of rats contained 10 per cent of the dried yeast. In this case, as with the better calf ration, no advantage was found from the addition of yeast. It was found, however, that the growth of rats on the poor calf ration was decidedly below that of the rats which received the good calf ration. Typical results are shown in figure 8. Rats 654 and 655 received the poorer ration without yeast and rats 649 and 651 the ration with the yeast addition.

CONCLUSIONS

1. The addition of vitamin B in the form of dried yeast to the rations ordinarily fed on dairy farms did not increase the rate of growth of calves from the age of 20 to 180 days.

2. No definite effect was observed on the health of calves as a result of supplementing their ration with dried yeast.

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A STUDY OF THE FACTORS AFFECTING THE GROWTH OF DAIRY HEIFERS[1]

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The many recent discoveries in the field of nutrition have necessitated a change in the methods of attacking nutritional problems. While for many years the chemical analysis of a feed was taken as the true index of its usefulness in a ration, we now know that feeds containing the same amount of protein, carbohydrates, and fat may differ widely in their physiological effect on the animal. Hart, McCollum, Steenbock, and Humphrey (1, 2) in an early study proved that growth and reproduction are seriously affected by limiting the ration of dairy heifers to the product of a single cereal plant. The heifers fed on the corn plant grew well, matured and showed early oestrus, and were physically strong in every respect. Those receiving the wheat ration grew at a fair rate until they reached 1000 pounds in weight, when growth ceased. They showed lack of vigor and evidence of physical weakness; even blindness finally resulted. They showed no oestrus. Similar, though not so marked, were the results obtained from feeding the oat ration. Later experiments bringing forth the accessory food factors and the difference in the quality of proteins have explained the reasons for many of the difficulties encountered in the studies of nutrition.

The fact that these qualities and limitations of feeds cannot be determined by chemical analysis has opened a new field in the study of nutrition. Only by means of actual feeding trials of the many grains, alone and in combination, is it possible to determine their physiological value; which determinations must be made before any constructive advance can be made toward the

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solution of certain problems confronting the dairy farmer of today.

One problem which has been of great interest to investigators for many years is that of reducing the cost of raising calves. Today in sections of the country where whole milk is sold, the problem of raising calves to replace the old and discarded cows, is becoming quite serious. From the beginning of time, milk has been regarded as the food best adapted to the complete nourishing of mammalia, and so far no food has been found which will completely take its place. Partial substitutes have met with a fair degree of success, and supplements to milk have helped to reduce the amount necessary to raise the calf. These are fed however in the form of a slop and require considerable time in preparation; and the best results from their use are obtained only under ideal conditions. Whether or not it will ever be possible to obtain a complete substitute for milk is questionable.

If such a food is obtained it will of necessity be fed in the form of a liquid, due to the nature of the calf's stomach; since a complete substitute for milk would mean a food which will completely take the place of milk at the time when nature intended the calf to be nourished solely on milk. Under experimental conditions this would not detract from the value of the experiment, but under practical conditions the time and exacting details connected with the preparation of such a substitute would probably make it prohibitive. The only alternative in this case would be to determine the earliest age at which a calf may utilize solid food as the sole source of nourishment.

The recent developments in the field of nutrition emphasize the necessity in this case of a thorough study of the various grains with a view of determining which feeds may be utilized by the calf at the earliest age, and to the best advantage. This would mean a thorough study of the factors affecting growth.

PURPOSE OF EXPERIMENT

It was with the idea of studying these factors that the present work was started. Only the factor of nutrition has been considered so far, with special attention being given to its effect on

body weight, skeletal growth, reproduction, milk production, and general physical health and development. Experiments are under way at this station to determine the effect of other factors such as temperature and humidity, age at first calving, heredity, and certain physiological factors such as the ductless glands.

GENERAL PLAN OF THE EXPERIMENT

Three groups of calves were used. The first group was weaned between thirty and forty days of age, and placed on a dry grain and hay ration. The second group was handled in a manner similar to group 1, but the calves were weaned at forty to fifty days of age. The third group was weaned at thirty to forty days of age as were the animals in group 1, but blackstrap molasses was added to the ration during the greater part of the feeding trial.

REVIEW OF LITERATURE

The study of the growth of dairy heifers has attracted considerable attention. Though only a few of the investigations have a direct bearing on the work reported here. Fohrman (3) weaned calves at sixty to seventy days of age and then placed them on a dry grain and hay ration. These calves grew and developed into normal, healthy animals. One of us (4) in making a similar study, weaned calves at sixty to seventy days of age. These animals also developed into normal animals. In both of these trials it was found that while growth, as measured by weight, was in some cases quite seriously checked shortly after the weaning period, the growth of the skeleton continued at a nearly normal rate. After a period of two to three months following the weaning period the animals made abnormal gains in weight. Waters (5) has shown that the body weight is much more easily influenced than the skeletal growth by the conditions to which the animal is subjected. Animals may continue to grow in skeleton and at the same time remain at a constant weight. It was shown that the tendency to recover was strong, following a period of adverse conditions. Eckles (6) studying the effects of the liberality of the ration, concluded that,

there was a strong tendency for animals to recover from retarded growth when conditions are favorable later. This may be accomplished by a more rapid rate of growth, or by prolonging the period of growth. If the retardation, especially in skeletal growth, has gone too far, the animals will not, however, reach the normal size.

There is conclusive proof, therefore, that an animal may be temporarily stunted, and yet reach the normal size for the breed if placed under favorable conditions later. The extent to which an animal may be stunted and yet reach the normal is not so well known. This would seem to be a point worthy of investigation.

That calves can not be raised on milk alone has been shown by Davenport (7). A calf which received only milk developed swelling of the joints and disturbances of the nerve centers. As soon as hay and straw were allowed, the calf improved rapidly. As much as one half a bushel of grain daily, to a five months old calf, did not satisfy its craving for food. It is interesting to note that this enormous consumption of grain did not cause any digestive disturbances. McCandlish (8) has also shown that milk alone will not supply all the nutritional wants of calves after they are a few weeks old. He concludes that "the lack of bulk may arrest development of the alimentary tract and prevent proper digestion of the nutrients supplied by the milk." These calves grew fairly well until they were two to three months old, but from this time on they did not thrive though they continued to gain slowly in weight for another thirty days; after which their live weight decreased gradually until the time of death. The body measurements appeared to increase about normally until the time the live weight increase ceased to be rapid, and from this time on the measurements were almost constant.

Feeding experiments in which dry grain and hay were used as the sole source of nourishment at as early an age as reported in this paper, do not appear in the literature so far as the authors could find. Reports of experiments where milk feeding has been supplemented by grain and hay are quite numerous, even at an age far below that at which milk alone has been found to be

inadequate. In most of these experiments corn, bran, oats, and alfalfa or clover hay, have played an important part. The reason for the good results obtained from these feeds is just becoming known. Steenbock and Boutwell (9) have shown that yellow corn is a more valuable source of the fat-soluble vitamine than white corn, and Steenbock and Gross (10) have shown that alfalfa contains the fat-soluble vitamine in comparatively large amounts. It is also a valuable source of mineral as shown by Hart, Steenbock and Fuller (11) and its proteins appear to be of good quality. While oil meal probably contains only a slight amount of the fat-soluble vitamine, it is high in protein, and its laxative nature has an important bearing on the physiological value of the ration. Wheat bran contains considerable phosphorus, lends bulk to the ration, and contains some of the water-soluble B vitamine. Osborne and Mendel (12) found the crude protein of wheat bran to have a higher value for the growing animal than the embryo, but according to Forbes and Beigle (13) wheat bran is unsatisfactory as a source of calcium. However, Hart, Steenbock and Fuller (14) state that ruminants consuming the usual roughage will ordinarily receive calcium enough for growth. In view of these findings the following grains were used in making up the rations used in the work reported here; yellow corn meal, old process oil meal, wheat bran and alfalfa meal. The alfalfa meal was used in place of the hay only for convenience in weighing.

With the idea of increasing the palatability of the ration, blackstrap molasses was added for a short period of time. Calloway (15) in studying the physical effect of low grade sugar cane molasses when fed to young calves, concluded that, "when calves begin to consume a little grain, they can be given as much as one to two ounces of blackstrap molasses with each feed with perfect safety." He states that the molasses should be increased gradually. The calves were started on molasses at an average age of four weeks. In the case of the calves reported here, the feeding of molasses caused scours in some cases while in others no harmful effects were noticed. This may be accounted for by the fact that there was no satisfactory method of mixing the molasses

with the grain or alfalfa meal; and as a result certain of the calves picked out the lumps of grain or alfalfa containing the molasses and in so doing received a higher percentage of molasses than would otherwise have been the case.

A great deal has been said regarding the use of minerals in the ration of dairy animals. In this study no minerals were used during the early part of the feeding trial. It was felt that the grain mixture and the alfalfa meal would supply the required minerals. It was noticed, however, that certain calves were eating dirt and licking the fence around the exercise yard, and for that reason calcium carbonate and raw rock phosphate were added to the grain mixture to see if such an addition would have any effect on the calves. Later, these minerals were placed in separate boxes accessible to the calves at all times. This amount was weighed when put into the boxes and at the end of ten days was weighed back. This was done with the view of determining whether or not the calves would express any special need for one mineral more than the other.

METHOD OF PROCEDURE

Animals used[2]

All pure bred female calves dropped in the Experiment Station herd during the period the experiment were used. They were not selected. It was not possible, therefore, to have an equal number of representatives of each breed. The letter following the number of each calf indicates the breed. As follows: a means Ayrshire, h, Holstein, j, Jersey, and s, Shorthorn.

Rations used and method of feeding

The calves were left with the dams for forty-eight hours and were then placed in individual pens where they were fed milk three times daily; the amount varying with the individual according to appetite and condition of bowels. The calves were

[2] The Experiment Station herd of Jerseys was sold to the University of California and for this reason the Jerseys used in this experiment were not kept on the experiment as long as were the animals of the other breeds.

allowed to run together between feedings. At an average age of four weeks, the calves were given a grain mixture and alfalfa meal. These feeds were placed in the individual feeding pens in separate containers at the time of the night feeding of milk. These containers were so arranged as to prevent the calf from tipping them over. At the end of the milk feeding period the grain and hay were placed in the containers at 5:00 p.m. and left there until morning, when the calves were turned out together in the community pen.

All milk, grain and alfalfa meal were carefully weighed, and any grain or meal left by the calves was weighed back and this amount deducted from the original amount. As soon as the calves reached one year of age, they were given the grain mixture which is used at this station for all growing dairy animals, and were also allowed all the alfalfa hay they would eat in place of alfalfa meal. They also received a small amount of corn silage. The hay and silage were not weighed. During the pasture season all calves over a year of age were turned out to pasture. The grain mixture consisted of 6 parts each of hominy and wheat bran, 4 parts each of old process oil meal and ground oats, and 2 per cent each of salt and raw rock phosphate.

The calves were watered twice daily. They did not have water while in the individual pens, hence did not drink while they were eating their dry grain and alfalfa meal. The calves were weaned gradually, ten days being allowed for the change from milk to the dry ration. The bedding consisted of rye straw.

Measurements

Eckels (16) in a study to determine the best methods of measuring the growth of dairy heifers, concluded that the growth of an animal could not be properly represented either by live weight or any body measurements alone. It was decided that the most satisfactory plan is to use both the live weight and some body measurement which represents skeletal growth, and for the latter it was concluded that height at withers is the most satisfactory. In this study, the calves were weighed every ten days, until they were one year of age. Weights were taken on the ninth, tenth

and eleventh days of each period, and the average of these three days was used as the weight for the tenth day. As soon as the calves reached one year of age, they were weighed every thirty days.

The height at withers and heart girth measurements were taken every thirty days from birth. The last named measurement was taken with the view of obtaining additional data on the growth of the skeleton. No check animals were used. All weight and height measurements were compared with the normal growth figures of each breed, established by Eckles (17). The curves shown, represent the percentage of the normal weight and height.

EXPERIMENTAL WORK

Group 1

The animals in this group consisted of 3 Jerseys, 2 Holsteins and 2 Ayrshires. They were allowed milk as previously described until they reached an average of thirty days of age; at which time they were gradually weaned until at forty days they were receiving only dry grain and alfalfa meal. The grain mixture during the early part of the trial consisted of 4 parts of yellow corn meal, 3 parts of old process oil meal and 1 part of wheat bran, and 2 per cent of salt. It was noticed that the calves had a tendency to scour so 2 parts of oil meal were used in place of 3 parts. These proportions of grains were used during the remainder of the trial. Calf 1j received the first mixture until she was 220 days of age; calves 2j and 3j until 185 days of age, and calves 4h, 5h, 6a, and 7a, until 130 days of age.

The calves were limited to 5 pounds of grain per day; no limit was placed on the alfalfa meal. An effort was made to induce the calves to consume as much grain as possible up to 5 pounds and also as much alfalfa meal. For this reason the amount placed in the feed containers was increased each day until it was found the calves were leaving some; the amount was then reduced slightly and increased again as soon as possible.

As previously mentioned the calves showed a tendency to eat a slight amount of dirt which was believed to indicate a lack of

minerals. To all outward appearances, however, the calves were healthy except that they were rather thin and did not show the finish of milk fed calves. Two per cent of raw rock phosphate and 2 per cent of raw limestone were added to the grain ration when the calves were at the following ages: Calf 1j, 240 days, calves 2j and 3j at 200 days and calves 4h, 5h, 6a, and 7a at 150 days of age. At the end of thirty days it was decided to leave the minerals out of the grain mixture and to place two boxes in the community pen, one containing raw rock phosphate and the other, raw limestone. As the experiment progressed and the animals which constituted groups 2 and 3 were added they also were turned out during the day in the community pen and had access to the mineral boxes. Ten pounds of the minerals were placed in the separate boxes and at ten-day intervals the amount remaining was weighed and in this way an approximate figure was obtained as the amount consumed by the calves. At the end of the month the total was divided by the number of calves running in the pens during that month. As can be seen this was not a very accurate method but it served the purpose in that it gave an opportunity to observe whether or not the calves would eat more of one mineral than another and also if the amount consumed would stop the calves from eating dirt. As shown by table 1, which gives the average amounts of the minerals consumed per calf per month, the amount decreased each month until it was almost negligible. The calves however did not show any outward effect from the use of the minerals. As before, certain individuals were noticed to eat dirt in very slight amounts. Apparently this was not due to any lack of mineral unless the minerals in the form fed were not utilized by the animals. However, it was decided to add 2 per cent of raw rock phosphate to the grain ration after the box method of supplying the minerals was discontinued.

Calves 6a and 7a were born only two days apart and as was the case with practically all of the Ayrshires, did not grow as well as the Holsteins. Neither did these two consume as much grain or alfalfa meal as did the other calves in this group. For this reason an effort was made to increase the palatability of the ration by

adding molasses with the view of inducing calf 6a to consume larger quantities of the feed. At 220 days of age 40 per cent of molasses was added to the alfalfa meal given to this calf and 10 per cent was added to the grain ration. She was continued on this ration until 330 days of age and in that time consumed 451 pounds of grain and 308.8 pounds of alfalfa, while calf 7a consumed 469 pounds of grain and 276 pounds of alfalfa. During this time calf 6a gained 145.7 pounds in weight, and calf 7a gained 130.8 pounds in weight. As can be seen there was very little difference in the amounts of grain and alfalfa consumed by

TABLE 1

Average consumption of minerals per calf per month

MONTH	RAW LIMESTONE	RAW ROCK PHOSPHATE
	pounds	*pounds*
1	0.760	0.31
2	0.446	0.53
3		0.153
4		0.362
5		0.000
6		0.270
7		0.204
8		0.000
9		0.057
10		0.028
11		0.028

the two calves and the gains made by calf 6a were only slightly better than those made by calf 7a.

In figure 1 are the curves which represent the percentage of the normal weight and height for these calves.

Table 2 gives the total gains in weight, height and heart girth measurements and total feed consumed from birth to 300 days of age for each animal in the three groups.

Group 2

The calves in this group consisted of 3 Jerseys, 2 Ayrshires, 2 Shorthorns and 1 Holstein. They were fed and handled in a manner similar to the calves in group 1 except that the weaning

period began at forty days of age instead of thirty. The grain mixture used for this group consisted of 4 parts of yellow corn meal, 2 parts of old process oil meal and 1 part of wheat bran and 2 per cent of salt. After the box method of feeding the minerals was discontinued as described under group 1, these calves received raw rock phosphate in their grain ration at the rate of 2 per cent of the weight of the total grain mixture. In figure 2 are the curves representing the average percentage normal weight and height for each breed represented in group 2.

Group 3

The animals in this group consisted of 6 Holsteins, 3 Jerseys, 2 Ayrshires and 1 Shorthorn. They were fed and handled in a manner similar to the calves in group 1 except that 10 per cent of blackstrap molasses was added to the grain mixture and 20 per cent to the alfalfa meal. Two per cent of raw rock phosphate was added to the grain mixture.

Two or three times it was necessary to leave the molasses out of the ration for a day or two as it appeared to cause scours. It may be that other factors were at work although it is believed the molasses was the cause since the calves in group 1 did not scour except during the period when the ration consisted of 3 parts of oil meal in place of 2. As previously explained the inefficient method of mixing the molasses with the grain and hay may have had something to do with the calves scouring. Through a more thorough mixing of the molasses in the ration the calves would not have received so high a percentage of the molasses.

DISCUSSION OF RESULTS

The calves in all three groups were surprisingly healthy during the greater part of the feeding trial. Scouring occurred only in the case of a few individuals and then only during the milk feeding periods and in the case of the calves in group 1 at the time when 3 parts of oil meal were used in place of 2 parts. A few of the calves in group 3 scoured somewhat at various intervals. This was believed to be due to the molasses. Collectively there was less trouble with scours than is usually experienced with milk fed calves.

TABLE 2

Total feed consumed and increase in weight, height and heart girth* from birth to 300 days of age*

CALF NUMBER	WEIGHT	HEIGHT	HEART GIRTH	MILK	GRAIN	HAY
			Group 1			
	pounds	*cm.*	*cm.*	*pounds*	*pounds*	*pounds*
1j	392.6	29.3	53.1	342.0	1,060.5	735.5
2j	315.3	32.0	56.0	222.0	1,025.0	612.5
3j	325 4	28 4	52 8	183 0	1,153 0	628 0
4h	417.3	28.4	57.6	281.0	1,210.0	851.5
5h	484.4	36.5	59.5	429 5	1,199 5	1,464 2
6a	205.7	18.1	37.9	418.0	740.0	389.3
7a	224.7	16.8	38.3	414.0	711.7	481.5
			Group 2			
8a	371.1	26.9	52.5	415.0	829 0	950.0
9a	325.0	23.5	52.8	387.5	930.5	599.0
10s	250.2	22.5	50.5	429.5	778.5	298.5
11s	297.9	25.5	51.1	350.0	973.0	450.0
12h	375.0	29.8	52.0	508.5	790.0	496.0
13j	317.7	29.5	55 0	361 0	1,014.0	801.0
14j	246.6	25.5	40.0	355.5	934.0	611.0
15j	332.0	29.7	53.1	392.5	995.0	678.0
			Group 3			
16h	401.6	35.4	49.6	374.5	1,150.0	1,069.8
17h	394.6	28.1	45.3	363.5	1,097.0	964.0
18h	366.6	32.3	51 6	318.0	1,046.0	955.0
19h	320.0	24.7	42.4	263.5	934.0	502.5
20h	152.3	18.5	28.3	329.5	497.5	304.5
21h	343.3	24.9	50.9	347.5	937.7	783.5
23j	299.4	31.1	46.1	338.0	1,099.0	682.0
24j	168.6	19.4	27.9	281.0	832.0	263.0
26a	169.7	16.0	32.7	201.0	443.1	302.0
27a	236.3	20.2	38.5	197 0	737 0	365.5
28s	255.5	23.8	40.6	132.5	883.0	313.0

Calf 2j—figures for height and heart girth are from forty days to three hundred days of age.

Calf 4h—figures for height and heart girth are from sixty days to three hundred days of age.

Calf 9a—figures for feed are from birth to two hundred sixty days of age.

Calf 12h—figures for feed are from birth to two hundred thirty days of age.

Calf 14j—figures for weight are from ten days to three hundred days of age.

Calf 20h—figures are from birth to two hundred fifty days.

Calf 21h—figures are from birth to two hundred ninety days.

Calf 24j—figures are from ten days to two hundred seventy days of age.

Calf 27a—figures are from ten days to three hundred days of age.

* Increase in height and heart girth is calculated from thirty days of age to the measurement taken nearest to three hundred days of age as shown on the individual tables of growth by thirty-day periods.

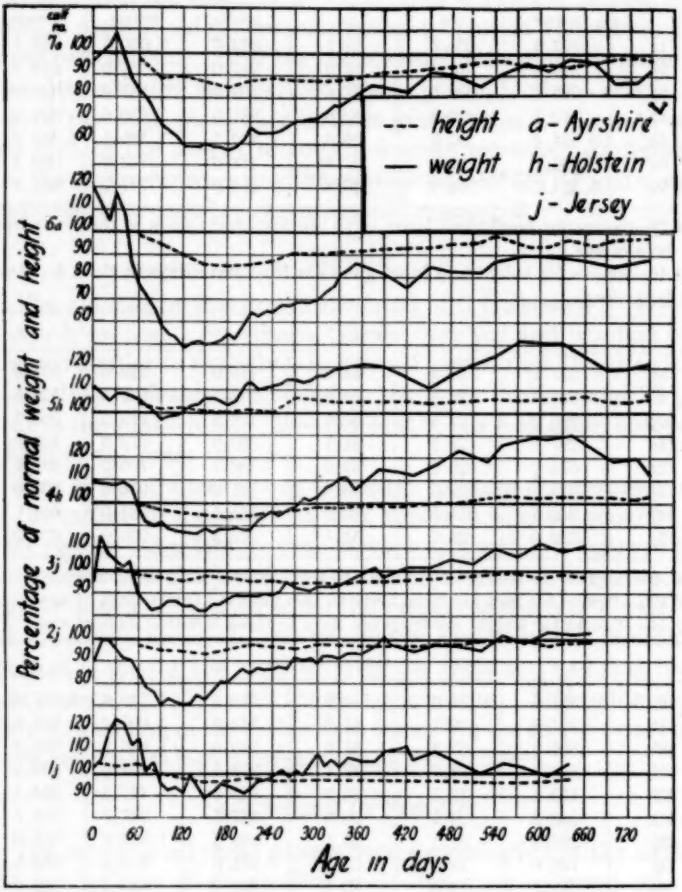

FIG. 1. GROUP 1, REPRESENTING THE PERCENTAGE OF THE NORMAL WEIGHT AND HEIGHT AT WITHERS

The calves in this group were weaned between thirty and forty days of age and were then placed on a dry grain and hay ration.

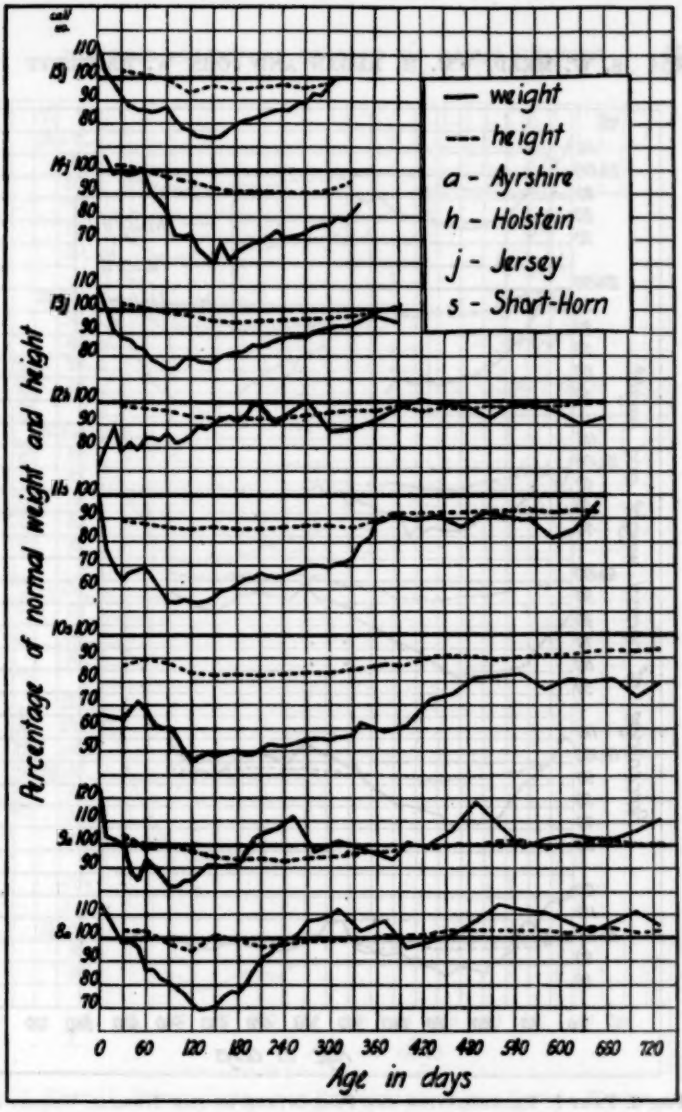
— weight
---- height
a - Ayrshire
h - Holstein
j - Jersey
s - Short-Horn
Percentage of normal weight and height
Age in days
0 60 120 180 240 300 360 420 480 540 600 660 720

FIG. 2. GROUP 2, REPRESENTING THE PERCENTAGE OF THE NORMAL WEIGHT AND HEIGHT AT WITHERS

The calves in this group were weaned between forty and fifty days of age and were then placed on a dry grain and hay ration.

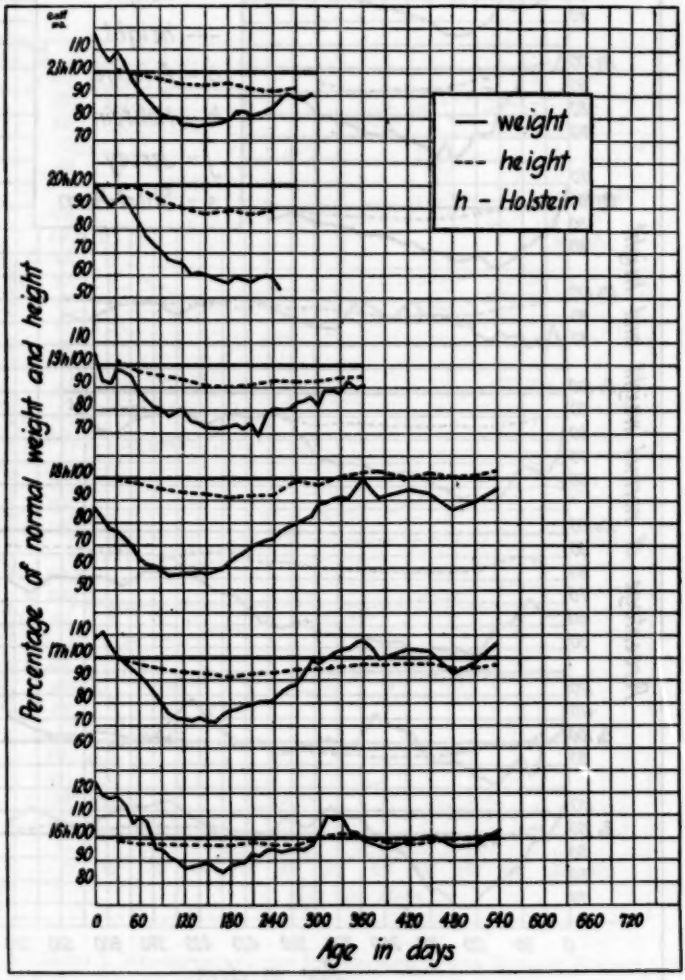

FIG. 3. PART I. REPRESENTING THE PERCENTAGE OF THE NORMAL WEIGHT AND HEIGHT AT WITHERS

The calves in this group were weaned between thirty and forty days of age and were then placed on a dry grain and hay ration. The ration received by these calves differed from that received by the calves in groups 1 and 2 in that 10 per cent of molasses was added to the grain mixture and 20 per cent to the alfalfa meal.

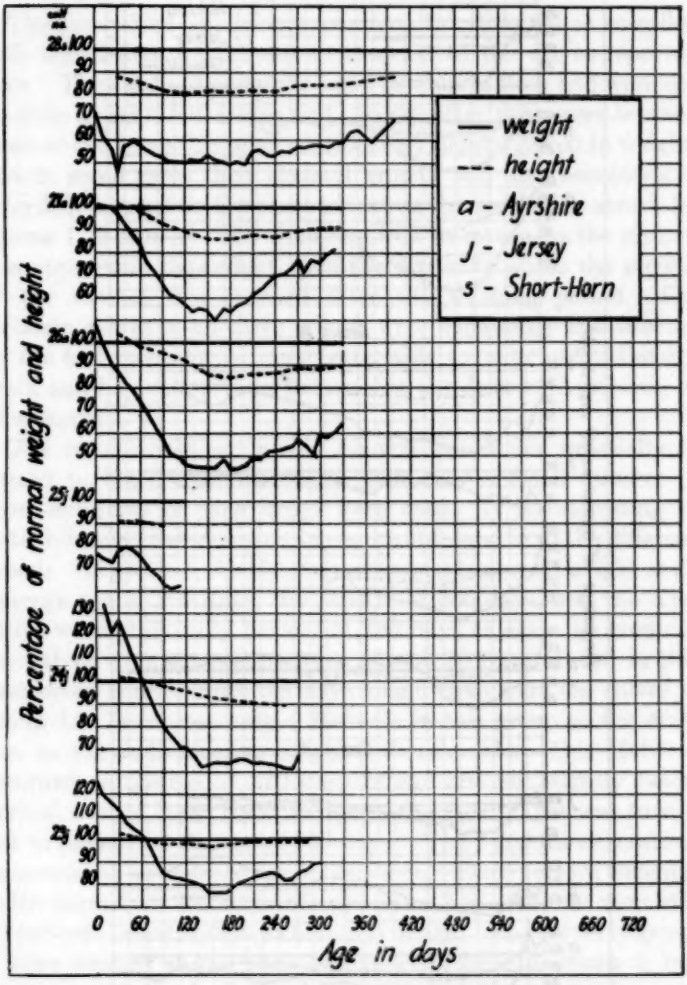
— weight
--- height
a - Ayrshire
J - Jersey
s - Short-Horn
Percentage of normal weight and height
Age in days
0 60 120 180 240 300 360 420 480 540 600 660 720

FIG. 3. PART II. REPRESENTING THE PERCENTAGE OF THE NORMAL WEIGHT AND HEIGHT AT WITHERS

The calves in this group were weaned between thirty and forty days of age and were then placed on a dry grain and hay ration. The ration received by these calves differed from that received by the calves in groups 1 and 2 in that 10 per cent of molasses was added to the grain mixture and 20 per cent to the alfalfa meal.

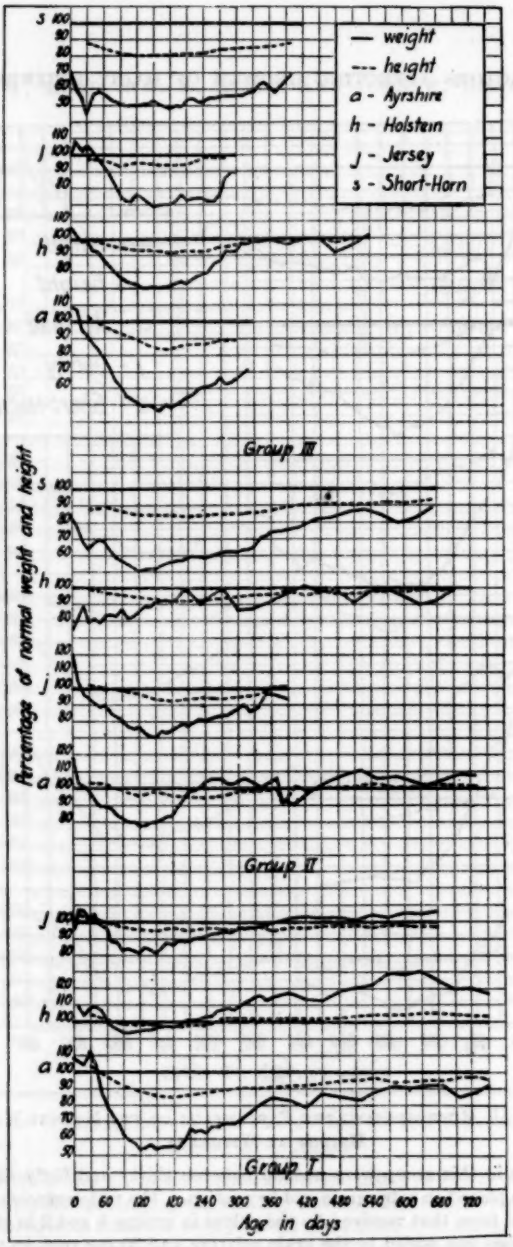

FIG. 4. REPRESENTING THE PERCENTAGE OF THE NORMAL AVERAGE WEIGHT AND HEIGHT AT WITHERS OF THE BREEDS REPRESENTED IN EACH OF THE THREE GROUPS OF CALVES

The pot-bellied condition so common to calves fed on so-called milk substitutes was absent in the case of the calves reported here. They did not carry the same amount of flesh and were not as slick as milk fed calves and shortly after they were weaned most of the calves dropped considerably below normal in weight, and in some cases their skeletal growth was also considerably retarded, but not to the same extent as the weight, as shown by figures 1, 2 and 3. The time required to return to the normal was apparently dependent upon the degree to which the growth of the animal was checked after the weaning period. The Holstein calves in all three groups were apparently less affected by the early weaning or were better able to make use of the dry grain and hay ration than were either the Jerseys, Ayrshires, or Shorthorns.

The results obtained are in no way conclusive especially in regard to breed characteristics, since only a small number of representatives of each breed were used. It is interesting to note, however, the variation in results obtained from the different breeds. In group 1, the Holsteins returned to normal weight at an average age of 200 days, the Jerseys at 360 days, and the Ayrshires were practically normal at 760 days of age. In group 2, the calves were weaned between 40 and 50 days of age, in this case being allowed milk ten days longer than were the calves in group 1. There was only 1 Holstein in this group so the error due to the individuality may be considerable. This Holstein returned to normal at 270 days of age but fell slightly below normal a little later, possibly due to the fact that it was turned out to pasture at the age of 230 days. The 2 Ayrshires returned to normal at an average age of 230 days. The 3 Jerseys were not quite normal at 390 days of age. The 2 Shorthorns were still 10 per cent below normal at 650 days of age. The calves in group 3 were weaned at the same age as were those in group 1, but received molasses in their grain and hay. It is not so easy to compare the results in this group with those in groups 1 and 2, since the calves at the time of this report were not as old as those in groups 1 and 2. However, the percentages of the normal for the Jerseys in both groups at the same age were practically the

same as was also the case with the Ayrshires. There were no Shorthorns in group 1, hence there is no basis for comparison. In group 3, the Shorthorn calf was still considerably below normal at 400 days of age. Comparing it with the Shorthorns in group 2, at the same age, there was a difference of 6.6 per cent in favor of the Shorthorns in group 2 who were weaned ten days later than those in group 3. There were 6 Holsteins in group 3, 4 of which had reached 360 days of age at the time of this report. Of these 4 one had practically reached normal at 290 days of age, one at 300 days, one at 360 days, and one was 93.6 per cent normal at 340 days. Of the others, one was only 54.8 per cent normal at 250 days and the sixth calf was 91.4 per cent normal at 290 days of age. For the most part they compare quite favorably with the Holsteins in group 1.

In making these comparisons the height at withers and heart girth measurements are not included since the skeletal growth was normal in most cases at an earlier age than was the growth in body weight. As shown by Eckles (18) and Waters (19) the body weight was much more easily influenced than the skeletal growth by the conditions to which the animals were subjected. The Ayrshires and Shorthorns were the only animals whose skeletal growth showed any great abnormality at any time and in these cases the height at withers approached normal at an earlier age than did the body weight; although in many cases after the weight had returned to normal the height at withers still remained slightly below normal as shown in figures 1, 2 and 3.

This may mean that the skeleton was slower to recover from retarded growth than the body weight or it may be that individuality was the limiting factor.

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THE IMPROVEMENT OF FLAVOR AND KEEPING QUALITY OF HAND-SEPARATOR-CREAM-BUTTER

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When pasteurization of cream for buttermaking was first introduced into the creamery, it was for the sole purpose of making the resulting butter a safer product. It was soon discovered however that pasteurization also influenced the flavor to some extent, thus it became less pronounced but of a more delicate character. Originally the same temperatures were employed for pasteurization of cream for buttermaking as for market milk. It was suggested later by practical creamery operators that somewhat higher temperatures for pasteurization would be beneficial when pasteurizing sour cream since it was claimed that the resulting butter would be of better flavor and that the keeping qualities would be increased. The work herein reported was carried out primarily for the purpose of determining the influence of temperature of pasteurization of sour cream on the flavor of the resulting butter, and the effect of acidity of sour hand separator cream at the time when it is churned.

HISTORICAL

When comparing results obtained by earlier investigators with those published more recently it will be noted that pasteurization of cream for buttermaking is gradually growing in favor. Fifteen or twenty years ago the quality advantages obtained from pasteurization when the resulting products were judged by commercial judges were insignificant if at all noticeable. There were various faults attributed to pasteurization such as overheated flavor, poor texture, etc., and it was held that sour cream could not be pasteurized without too great a loss of butterfat in the

buttermilk. Farrington and Russell (1) determined that sour cream containing over 30 per cent fat might be successfully pasteurized while sour cream containing in the neighborhood of 20 per cent fat would cause a greater fat loss in the buttermilk. Lee (2) found that a slight gain in quality was made as a result of pasteurizing hand separator cream; the gain was rather insignificant while the butter was fresh but was considerably greater after cold storing. It was not considered that pasteurization affected the body or texture of the butter. Curdling of the cream by pasteurization increased the loss of fat in the buttermilk.

Dean (3) found an increased loss of fat in the buttermilk as a consequence of increased acidity in the cream at the time of pasteurization. Mortensen, Gaessler and Cooper (4), in comparing raw cream butter with butter made from pasteurized cream obtained a gain of 0.41 point in favor of the latter when using flash heat at 180°F. and a gain of 2.22 points in favor of the pasteurized cream butter when the holding method of pasteurization was employed. Larson, Fuller, Jones, Gregory and Tolstrup (5), found that butter made from cream pasteurized at 180°F. by flash heat retained its keeping qualities better than butter made from cream pasteurized at 140°F., for 25 minutes or from cream pasteurized at 160°F. for ten minutes.

Several attempts have been made to improve over-ripe cream by partial neutralization. Dean (3) reports that in accordance with his experiments butter scored about 3 points higher after adding milk of lime to the cream before pasteurization and 3½ points higher after adding the milk of lime after pasteurization than when the cream was not neutralized.

Ramsay (6) recommends carbonate or bicarbonate of soda for neutralization, and claimed that the carbon dioxide formed during neutralization is impeded in its passage through the cold mass of cream on account of the viscosity of the latter. This viscosity is lessened when the cream is heated to 170°F., as in pasteurizing and the gas then escapes into the air. As it rises through the mass of cream it carries with it, it is claimed, mechanically the volatile substances which give the cream an unpleasant smell and taste. The result is a product from which unpleasant odors

and taints have been removed. In 1920 Ramsay (7) reported that the mixing of cream and neutralizing agent was more rapid and uniform with the flash method of pasteurization than with the holding method. Wide differences were found in the efficiency of holding machinery in actual use in creameries.

METHODS

Only sour cream was used in the following experiments. The cream was mixed in a cream ripener and divided into two lots which were pasteurized at different temperatures. Comparisons were made between cream heated to 145°F. for thirty minutes and cream heated to 170°F. for twenty minutes, and 180° for twenty minutes. All conditions were as near as possible the same excepting the factor that was being investigated.

Two 10-pound tubs were shipped from each churning to both New York and Chicago. The tubs were numbered consecutively and one of a pair was marked "A" and the other "B." The "A" tubs were scored immediately upon arrival on the market. Both tubs were then placed in cold storage at a temperature of 0°F. After about two months the "A" tubs were rescored while "B" tubs remained in storage for a longer period. Credit is due to the Judges Messrs. P. H. Kieffer, C. W. Fryhoffer, James Rowland and W. N. Mapes, all of New York and Mr. G. W. Bull, Chicago,[1] and to our A. R. Morgan, who assisted us in conducting the work at the college creamery.

Pasteurization at 145°F. vs. pasteurization at 170°F.

Comparing results from seventeen experiments, it was found that eight samples from the cream heated to 170°F. scored the higher while fresh, five samples from the cream heated to 145°C. produced the best result, while both samples scored the same in four experiments. The average score on flavor was 34.6 for butter made from cream pasteurized at 170°F. as against 34.2 for butter made from cream pasteurized at 145°F.

[1] Few of the samples were not taken out of storage for scoring at the proper time, such samples were not considered in our calculations.

After two months storage eleven of nineteen experiments favored the high temperatures while in six of the experiments the lower temperature produced the higher scores and in two experiments the scores were the same. The average score on flavor was 34.5 for butter made from cream pasteurized at 170°F and 33.7 for butter made from cream pasteurized at 145°F.

After nine months storage five of eleven experiments favored the butter made from cream pasteurized at 145°F. Three experiments came out in favor of the higher pasteurizing temperature and in three experiments the results were the same for both methods. The average score on flavor was 32.5 for the butter made from cream pasteurized at 145°F. and 31.8 for butter made from cream pasteurized at 170°F.

Influence of pasteurizing temperature on quality of resulting butter

NATURE OF EXPERIMENT	NUMBER OF EXPERIMENT	AGE OF BUTTER WHEN SCORED	SCORE ON FLAVOR		
			145°F.	170°F.	180°F.
145°F. vs. 170°F.	17	Fresh	34.2	34.6	
	19	2 months	33.7	34.5	
	11	9 months	32.5	31.8	
170°F. vs. 180°F.	9	Fresh		34.4	33.9
	6	2 months		33.2	33.7
	8	9 months		32.6	32.3

Pasteurization at 170°F. vs. pasteurization at 180°F.

Nine experiments were conducted for the purpose of determining if there would be any difference between quality of butter produced from cream pasteurized at 170° and that from cream pasteurized at 180°F. When the butter was fresh, four of the nine experiments came out in favor of a temperature of 170°F. while three were in favor of 180°F. and in two experiments the scores were the same. The average score on flavor for butter made from cream pasteurized at 170°F. was 34.4 and for butter from cream pasteurized at 180°F. 33.9. Butter made from cream pasteurized at 180°F. was often criticized as being over-heated.

After two months storage three of six experiments came out in favor of the higher pasteurizing temperature, one experiment came out in favor of the lower temperature and two were the same for both. The average score on flavor was 33.2 for the butter made from cream pasteurized at 170°F. and 33.7 for cream pasteurized at 180°F.

After nine months storage, four of eight samples came out in favor of the 170°F. temperature, two in favor of 180°F. and two the same for both methods. The average score on flavor was 32.6 for the butter made from cream pasteurized at 170°F. and 32.3 for butter made from cream pasteurized at 180°F.

REDUCTION OF ACIDITY IN SOUR CREAM

Results reported from former experiments conducted at this and other stations seem to indicate that when sweet cream of high quality is received the butter made from cream ripened to a medium acidity possesses the better qualities during the first one or two months but deteriorates faster than butter made from sweet cream. It was therefore our object to determine if the acidity of the cream at the time of churning would be of equal importance when the cream was originally sour and of rather poor quality. It was also the purpose of the following experiments to test out certain methods of manufacture recommended for sour cream. Part of the acidity in the cream was reduced, and for that purpose neutralizing agencies such as lime, viscogen,[2] and bicarbonate of soda (baking soda) were used. The following experiments were carried on in the laboratories in the dairy department in connection with the instructional work.

Conclusive proofs have been presented by this and other stations to the effect that sour cream of poor quality is improved by neutralization, but it has also been held by many buttermakers

[2] Viscogen is a sucrate of lime solution and was made in accordance with Bulletin No. 54, Wisconsin Experiment Station, by dissolving two and one-half parts by weight of a good quality of cane sugar in five parts of water, and one part of quicklime gradually slacked in three parts of water, the two solutions being mixed. The mixture was agitated at frequent intervals and after two or three hours allowed to settle until the clear supernatant fluid could be siphoned off.

that a good starter was of greater importance than neutralization. For the purpose of determining the correctness of that statement the following tests were made.

Butter obtained from partly neutralized cream churned without the addition of starter vs. butter from untreated cream to which starter was added

Cream, usually of high per cent acidity, was mixed in a vat and divided into two lots. One was partly neutralized and pasteurized, no starter being added and the other lot was merely pasteurized and a starter added after the temperature had been brought down to about 60°F. Both lots of cream were cooled to 40°F. and left at that temperature until churning. The greatest possible effort was made to have all other conditions the same for the two lots.

Two 10-ten pound tubs from each churning were shipped to New York or Chicago. They were scored by commercial judges while fresh, and after two months storage. The butter was held in cold storage at about 0°F.

Three out of nine experiments came out in favor of the neutralized cream butter while fresh, five came out in favor of the other while one scored the same for both. The average score on flavor was 33.8 for the neutralized cream butter and 34.4 for the other.

After two months storage the neutralized cream butter scored highest in six of eight experiments, the other scored highest in one and the scores were the same in one experiment. The average score on flavor for the neutralized cream butter was 34.2 against 33.0 for the other.

Neutralized vs. untreated cream butter, starter added to both

Five experiments were conducted to determine results when the same per cent of the same starter was added to each lot. The first scoring was done from one to two months after the butter was made while the second scoring was done after the butter was about nine months old.

At the first scoring, four neutralized cream samples ranked higher against one for the butter made from cream not neutralized.

The average score on flavor for the neutralized cream butter was 33.8 and 32.9 for the butter made from untreated cream.

After nine months four neutralized cream samples ranked higher against one for the butter made from untreated cream. The average score on flavor was 32.6 for the neutralized cream butter against 30.2 for the untreated cream butter.

Pasteurization experiments with neutralized cream

NATURE OF EXPERIMENT	NUMBER OF EXPERIMENT	AGE OF BUTTER WHEN SCORED	SCORE ON FLAVOR			
			Neutralized without starter	Untreated with starter	Neutralized with starter	Ripened neutralized cream
Neutralized cream without starter vs. untreated cream with starter	9	Fresh	33.8	34.4		
	8	2 months	34.2	33		
Neutralized vs. untreated-cream butter. Starter added to both	5	Fresh		32.9	33.8	
	5	9 months		30.2	32.6	

DISCUSSION OF RESULTS

From the above data, it seems fair to conclude that sour cream pasteurized at 170°F. by the holding method produces a slightly superior product than is produced from the same cream when it is heated to only 145°F. It seems however that butter made from cream pasteurized to a high temperature does not keep as well over a long period of time as butter made from cream heated to a lower temperature. It may be possible that the exposure of the fat to a higher heat hastens oxidation. Pasteurization at 180°F. for twenty minutes did not give as satisfactory results at 170°F., the resulting butter often being criticized for having an overheated flavor.

It seems to hold true when handling sour cream for buttermaking that the flavor of the product is improved and the resulting butter deteriorates about in proportion to the per cent of acid contained in the cream at the time of churning. For these reasons some of the creameries are today neutralizing part of the

acidity in sour cream before churning. This practice is undoubtedly to the advantage of producers who live on cheap land in territories where dairying has not been developed and for that reason have to ship their cream long distances. This system should however not be encouraged in the better dairy districts where the producers live within few miles of a creamery as in that case it has a tendency to cause the producers as well as creamery operators to become somewhat indifferent about quality of the raw material. The dairyman who is farming rather high priced land will obtain a profit from his dairy herd only when he is producing a product which is of high quality.

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THE RELATION OF NATURAL ACIDITY IN MILK TO COMPOSITION AND PHYSICAL PROPERTIES

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The reaction of milk has long been a subject of scientific, as well as practical, interest. On standing under ordinary conditions milk will become sour due to the formation of lactic acid from bacterial action. But aside from this, the milk of most animals is slightly acid when drawn. This natural acidity varies from one individual to another, and, even from one quarter of the udder to another in the same individual. It is the purpose of this work to find what constituents in milk cause these differences in acidity, how the properties of milk are affected by these factors, and to contribute data which may add to the general knowledge of the intricate composition of milk.

In some of the earliest work, investigators reported that milk would change blue litmus paper to red and red to blue (1). To describe this condition the term "amphoteric" was applied. It is hardly conceivable to us now how this could be true. It is likely, however, that if litmus paper be left in contact with some kinds of milk sufficiently long that the dye would be adsorbed by the colloids of the milk, and what was really a fading out of the paper was described as a color change.

A little later when other indicators than litmus were employed, there seemed to be some justificatoin of the idea. Thomsen (2) found that milk was acid to phenol phthalein and alkaline to lacmoid. Of course, we see it in our day as a demonstration of the fact that the hydrogen ion concentration of average milk lies between the points at which these indicators change colors.

Quantitative determination of acidity in milk began with Soxhlet and Henkel (3) who titrated with standard alkali using phenol phthalein as indicator. That original procedure has not

been changed to the present time except in the method of expressing the results and in the nature of alkali used.

Measurement of concentration of hydrogen ion in milk was first carried out by Foa (4) and a large number of measurements made since that time have shown the average for cow's milk to be about pH 6.5, with variations from 6.3 to 7.2.

Though some determinations of pH were made in this work, particular attention was given to acidity by titration. It is believed that results obtained by this method are more useful in judging the condition of milk, as well as changes taking place in it. The very nature of milk with its high content of buffer substances is such that the pH tends to remain constant regardless of additions or changes. Unless otherwise stated, the term "acidity" in this paper will refer to acidity of titration.

The majority of writers have believed acidity in milk to be due to one or all of the following substances: monobasic phosphates, casein, acid citrates and carbon dioxide. Lactic acid is known not to be present in freshly drawn milk but the acidity is generally calculated in terms of the percentage of lactic acid for the sake of convenience.

The milk of individual cows has for a long time been known to vary in acidity. Some factors which influence acidity as well as the composition of milk are—health of cow, age, breed, feed, period of lactation, differences in morning and evening milk, different portions of the same milking, and different quarters of the udder. In this work no effort was made to collect data regarding physiological causes for variations in acidity. Samples of milk from a large number of cows were titrated and those were selected for study which showed highest and lowest values, together with various points between, regardless of their sources; all animals were, however, fed similarly, and all were apparently in good health. On those chosen, a large number of analyses were first made the results of which are given in table 1.

Acidity was determined by titrating 20 cc. of milk, undiluted, with 0.1 N sodium hydroxide using 1 cc. of neutralized phenol phthalein solution (5 grams in 1 liter 50 per cent alcohol), and calculating results in terms of percentage lactic acid.

TABLE 1

COW NUMBER	PER CENT ACIDITY	SPECIFIC GRAVITY	PER CENT TOTAL SOLIDS	PER CENT FAT	PER CENT SOLIDS NOT FAT	PER CENT LACTOSE	PER CENT TOTAL PROTEIN	PER CENT CASEIN	PER CENT ALBUMIN	PER CENT BY VOLUME		PER CENT CITRIC ACID	PER CENT ASH	ALKALINITY OF ASH	PER CENT P_2O_5	PER CENT CaO
										Total CO_2	Free CO_2					
3	0.225	1.0301	13.34	3.90	9.44	5.05	3.30	2.49	0.731	8.00	4.07	0.191	0.733	60.2	0.2719	0.1631
19BF*	0.207	1.0331	12.31			5.15	3.33	2.65	0.675				0.810		0.2826	0.2125
20	0.202	1.0290	13.56			5.23	2.91			7.13	3.92	0.142	0.743	52.7	0.2534	0.1568
24	0.194	1.0319	13.65			4.73	3.80						0.811		0.2849	
21	0.192	1.0280	12.09			5.65	2.94						0.737		0.2277	
16	0.157	1.0282	11.72	2.60	9.12	4.87	2.92					0.199	0.709	57.2	0.2025	0.1450
Herd	0.153	1.0296	12.34	3.80	8.54	4.88	2.98			9.93	4.18		0.729	56.4	0.2156	0.1515
22	0.126	1.0261	11.69			4.15	3.06						0.800		0.2148	
23	0.121	1.0277				4.80	2.77	2.14	0.626	9.42	4.63	0.180	0.715	52.5	0.1753	0.1527
18	0.112	1.0270	11.30	3.40	7.90	4.35	2.85			14.10	5.45	0.116	0.771	54.7	0.1660	
19LH†	0.108					3.25	2.82	1.70	1.114				0.822		0 1962	0.1511

* Both front udders of cow 19.
† Left hind udder of cow 19.

Determination of total carbon dioxide was made by adding 30 cc. of 20 per cent lactic acid to 300 cc. of milk and passing a stream of carbon dioxide-free air through the boiling liquid into absorption tubes for one hour. "Free carbon dioxide" is that which could be removed from the untreated milk in the cold during a one hour period.

Alkalinity of ash was determined by adding an excess of 0.1 N nitric acid to the ash, boiling for a short time and titrating back with standard alkali using methyl orange as indicator.

Other determinations were made by the usual methods.

With decreasing acidity there is noted a general, though not regular, decrease in specific gravity, total solids, solids-not-fat, lactose, protein, casein, but a somewhat more regular decrease in P_2O_5. Similar observations have been made on some of these points by Hanne (5), Henkel (6), Allemann (7,) and Van Slyke and Baker (8), and others. There seems to be no striking relation between acidity and albumen content, citric acid, ash, alkalinity of ash, nor CaO. Low acid milk certainly has less nutritive value than high acid milk.

More careful attention was next given to those constituents which have been generally believed to contribute to the acidity of milk—carbon dioxide, citrates, casein, and phosphates.

RELATION BETWEEN CARBON DIOXIDE AND ACIDITY

Carbon dioxide is a natural constituent of freshly drawn milk and must without doubt affect the acidity to some extent. Taking the values for free carbon dioxide found in table 1, and calculating into terms of its equivalent in percentage lactic acid, the following results are obtained: Cow No. 3—0.016; 19 BF—0.016; herd—0.017; 23—0.018; 18—0.022. Since no particular pains were taken to prevent loss of carbon dioxide from the milk from the time of drawing samples until the determinations were made, these values may be considered as minimum.

Decrease in acidity on boiling or pasteurizing milk can be in part attributed to loss of carbon dioxide. A number of samples were boiled under vacuum at temperatures always below 50°, under which conditions there is little possibility of changes taking

place other than loss of the gases. The decreases in acidity were as follows: Cow No. 3—0.012; 20—0.018; 25—0.014; 16—0.013; herd—0.013; 23—0.018. Values here obtained are seen to be not far from those recorded in the preceding paragraph.

Differences in acidity between the various samples of milk, however, are distinctly not related to carbon dioxide. In fact the milks of low acidity contain somewhat more than those of high. Similar results were reported by Van Slyke and Baker (9). It can only be concluded that a part of the natural acidity is regularly attributable to the content of this gas. Calculated as lactic acid it may amount to 0.01 to 0.02 per cent; though if care be taken to prevent loss of carbon dioxide from time of drawing milk until the determination is made, somewhat higher results should be expected. Also when milk has been stored for a long time or transported long distances the amount of carbon dioxide may be less. These figures can be taken to represent average conditions.

RELATION BETWEEN CITRIC ACID CONTENT AND ACIDITY

It has often been shown that milk contains fairly large amounts of citric acid. This is no doubt combined with more or less base as citrate.

A few solutions were prepared containing citric acid and in one case citric acid with Ca ion present. With the addition of sodium hydroxide these were brought to pH values approximately equal to that of milk. Each solution was titrated to the phenol phthalein endpoint and the acidity calculated as lactic acid. The results are given in table 2.

On the assumption that the condition of the citrates in milk is similar to that in these solutions, it is evident that a part of the acidity of milk is due to this class of salts. However, the effect cannot be large and lies possibly between the values of solutions 3 and 4—in the neighborhood of 0.01 per cent acidity.

Since it was seen that milk of varying acidity did not show corresponding variations in citric acid content, the differences cannot be due to this constituent; its effect must be similar to that of carbon dioxide, rather constant.

RELATION BETWEEN CASEIN AND ACIDITY; EQUILIBRIUM BETWEEN THE VARIOUS CONSTITUENTS OF MILK

While most writers believe that casein is the cause of but a part of the acidity of milk, there are two extreme views: Bordas and Touplain (10) are of the opinion that there are neither free acids nor acid salts in milk, but that all the acidity is due to casein, while Van Slyke and Bosworth (11) conclude that casein is present as neutral calcium caseinate and can exert no influence on the acidity.

It has long been known that the addition of sodium citrate to milk inhibits rennet coagulation. This is commonly explained on the theory that in clot formation calcium ion must be available for combination with the casein and when an excess of citrates are

TABLE 2

SOLUTION NUMBER	PER CENT CITRIC ACID	RATIO— MOLS. NaOH: MOLS. CITRIC ACID	PER CENT CaO AS $CaCl_2$	pH	CC. OF 0.1 N NaOH PER 20 CC. SOLUTION	PER CENT ACIDITY AS LACTIC ACID
1	0.2290	2.75:1	0	6.387	0.6	0.027
2	0.2290	2.84:1	0	6.728	0.4	0.018
3	0.1145	2.84:1	0	6.889	0.3	0.014
4	0.1550	2.92:1	0.05	6.483	0.18	0.008

present unionized calcium citrate is formed thus preventing the combination. Addition of casein to milk has an effect on rennet coagulation similar to that of the alkali citrates (12), the explanation being the same. On the other hand, addition of calcium ion greatly hastens rennet action.

There should be no reason to doubt that for every change in the proportion of the constituents there is a new condition of equilibrium. Casein combined with calcium in amount neutral to phenol phthalein could not remain in contact with a solution of acid salts such as has been found in milk without yielding to those salts some of its base until a condition of equilibrium is established.

A solution was prepared from purified casein and calcium hydroxide, adjusting with acid until just neutral to phenol phthalein, pH = 8.50, also there was prepared a solution containing mono- and di-basic phosphates and alkali citrates with pH = 5.58.

When the two solutions were mixed in equal proportions the resulting pH was 6.49. Base must, therefore, have passed from casein to phosphates to effect this change in pH. As a result the casein must afterward have been acid to phenol phthalein and required alkali to bring it to a point neutral to that indicator. Since the resulting mixture had a hydrogen ion concentration similar to average milk it follows that the casein of milk must be a cause of part of the acidity as determined by titration with phenol phthalein.

Some experiments which apply very strikingly to this hypothesis were reported by Loeb (13). He showed that it requires about 3.5 cc. of 0.1 N alkali to change the pH of a solution of 1 gram of casein from 6.5 to 8.5. This change corresponds to the change in pH when milk is titrated. Using these figures and considering milk to contain 2 to 3 per cent casein, the acidity due to this factor calculated into terms of lactic acid would be 0.063 to 0.095 per cent.

In this work a solution of casein (2.32 per cent) was prepared by adjusting with $Ca(OH)_2$ and weak acid until a pH of 6.66 was attained, and in a similar way sodium caseinate (2.53 per cent casein) with pH 6.66 was made. In former case 1.2 cc. 0.1 N alkali was required to bring 20 cc. to the phenol phthalein end point and in the latter 1.9 cc. Calculated into terms of lactic acid, the former is 0.054 per cent, the latter—0.085 per cent.

On account of the strong buffer action of casein and on account of the complications entering into the equilibrium of milk constituents it is difficult to judge with any great degree of accuracy just what part of the acidity is to be attributed to casein. From the above results, however, it is concluded that 0.05 to 0.08 per cent is due to that factor.

It has already been show that generally milk with high acidity has somewhat larger amounts of casein. It is, therefore, certain that a part of the differences in acidity between various samples is due to this. Yet, as the above calculations show, any possible variations in acidity due to casein cannot be more than a small part of the great differences in acidity actually found in the samples.

RELATION BETWEEN ALBUMIN AND ACIDITY

Loeb found also that it required about 1.5 cc. of 0.1 N sodium hydroxide to change a solution containing 1 gram of egg albumin from pH 6.5 to 8.5. Assuming that lactalbumin reacts in this respect similar to albumin from egg, the titration values for milk containing 0.6 to 0.8 per cent would be 0.008 to 0.011 calculated as per cent lactic acid.

Since no regular relation was found between the percentage of albumin and total acidity this could not be a factor except in contributing approximately a fixed share to the acidity of all milks.

THE RELATION BETWEEN PHOSPHATES AND ACIDITY: A STUDY OF MILK SERUM

As has already been pointed out there was found a distinct variation in P_2O_5 with the acidity. Hanne (14) reports similar observations; Van Slyke and Bosworth (15) conclude that acidity in milk is due exclusively to phosphates.

Serum was prepared from a number of samples of varying acidity. The milk was first skimmed, then passed through a Pasteur Chamberlain filter, the first 75–100 cc. being discarded. In table 3 will be found the acidity of the original milk together with that of the filtrates, and the P_2O_5 content of the latter.

Close comparisons cannot be made between the results obtained on the serum and on the whole milk since the weight relations are not equivalent–100 grams of milk produces much less than 100 grams of serum. Furthermore, as the filter continues to run there is an increasing accumulation of insoluble constituents which possibly shifts the equilibrium and effects the composition of the filtrate. However, it is apparent that practically the entire differences in acidity between the various samples are found in the serum. Since casein is here eliminated from consideration and since the only constituent of importance in the serum that can influence acidity is the phosphate, it must be concluded that differences in natural acidity are due almost entirely to the phosphates.

The actual percentage of phosphorus show much more striking differences in the serum than in the milk. However, no absolute correlation can be made between P_2O_5 and acidity, since the latter depends not only upon the total amount of phosphate but also upon the ratio of monobasic to dibasic salt.

TABLE 3

COW NUMBER	ACIDITY OF MILK	ACIDITY OF SERUM	PER CENT P_2O_5 IN SERUM
20	0.212	0.112	0.1408
24	0.194	0.090	0.1152
21	0.192	0.094	0.1082
Herd	0.153	0.076	0.1000
22	0.126	0.040	0.0852
18	0.112	0.031	0.0622

TABLE 4

COW NUMBER	ACIDITY BY TITRATION	pH	pH: HCl ADDED	pH: NaOH ADDED	DIFFERENCE IN pH: HCl ADDED	DIFFERENCE IN pH: NaOH ADDED
3	0.225	6.432	6.007	6.914	0.425	0.482
20	0.202	6.483	6.024	6.997	0.459	0.514
24	0.194	6.531	6.140	7.024	0.391	0.493
21	0.192	6.495	6.049	7.057	0.446	0.562
16	0.157	6.675	6.149	7.298	0.526	0.623
Herd	0.153	6.690	6.166	7.301	0.524	0.611
22	0.126	6.919	6.381	7.651	0.538	0.732
23	0.121	6.767	6.181	7.501	0.586	0.734
18	0.112	6.898	6.281	7.680	0.607	0.782

HYDROGEN ION CONCENTRATION AND BUFFER ACTION

Hydrogen ion concentration was determined by the Rice and Rider (16) procedure on a number of samples of milk of varying acidity; also, on each sample was determined the pH after addition of 8 cc. of 0.1 N hydrochloric acid to 92 cc. of milk and also with 8 cc. of 0.1 N sodium hydroxide to 92 of cc. milk.

In table 4 will be found the results. It is seen that there is a regular increase in hydrogen ion concentration (decrease in pH values) with increase in acidity by titration, though the former differences cannot be said to be as marked as the latter.

It is shown, also, that the addition of acid and alkali to high acid milk changes the pH much less than when low acid milk is similarly treated. This is to be expected since the proportion of phosphate, particularaly, and of casein is greater in this class of milk; it is the influence of these substances acting as buffers that gives the milk that property.

The fact that high acid milk exhibits a strong buffer action is important in the consideration of the development of lactic acid acidity. For here it is necessary that a larger amount of acid be produced to change the pH than in low acid milk. Differences in pH would not, therefore, be as sensitive a means of determining degree of souring as titration figures.

EFFECT OF DILUTION ON ACIDITY OF MILK

Many investigators have noted that when milk is diluted with water, considerably less alkali is required to bring it to the phenol phtalein endpoint than when the undiluted milk is titrated. This has been attributed by some to hydrolysis of the phosphates (17) and by others to the hydrolysis of the calcuim caseinates (18).

In table 5 is shown the effect of dilution on the titration values of samples of different acidities. In the one case 20 cc. of sample was titrated directly with 0.1 N sodium hydroxide, and in the other, to 20 cc. was added 200 cc. of water before titration. It was found that dilution with more than this amount did not further reduce the acidity appreciably.

It is seen that dilution affects the titration values of high acid milk more than those of low acidity, which would indicate that phosphates have much to do with the effect.

A few samples of serum were titrated similarly, with and without dilution, when it was found that about the same percentage decrease in acidity was produced.

While this shows that constituents other than casein have much to do with the reduction of acidity on dilution, it was found on experimenting with solution of calcium and sodium caseinates already referred to, that there was here also a reduction of acidity on dilution but in somewhat smaller proportion than was found in the milk and serum.

It must be concluded, therefore, that both phosphates and caseinates contribute to the decrease in acidity on dilution.

TABLE 5

SAMPLE NUMBER	ACIDITY. NO DILUTION	ACIDITY. DILUTED 10 TIMES	DIFFERENCE	PER CENT DECREASE
3	0.216	0.149	0.067	31
1	0.185	0.122	0.063	34
26	0.180	0.104	0.076	42
2	0.176	0.117	0.059	33
4	0.168	0.113	0.055	33
17	0.180	0.063	0.045	42
15	0.095	0.054	0.041	43
18	0.086	0.050	0.036	42
Serum 1	0.054	0.036	0.018	33
Serum 2	0.045	0.023	0.022	49
Ca-caseinate	0.050	0.041	0.009	18
Na-caseinate	0.086	0.063	0.023	27

TABLE 6

COW NUMBER	ACIDITY	FREEZING POINT	PER CENT LACTOSE	PER CENT CHLORINE	SPECIFIC CONDUCTIVITY $\times 10^{-4}$ AT 20°
3	0.225	−0.547	5.05	0.0551	41.78
19BF	0.202	−0.553	5 15	0.0634	47.67
20	0.202	−0.546	5.23	0.0583	42.50
24	0.194	−0.552	4.73	0.0896	46.42
21	0.192	−0 550	5 65	0.0743	43.95
16	0.157	−0.547	4.87	0.0890	47.99
Herd	0.153	−0.547	4.88	0.0837	44.42
19BH	0 140	−0.553			61.17
22	0.126	−0.550	4.15	0.1522	60.67
23	0.121	−0.545	4.80	0.1082	49 83
11	0.121				49.00
18	0.112	−0.557	4.35	0.1660	56.70
19LH	0.108		3.25	0.1763	

THE RELATION BETWEEN ACIDITY, OSMOTIC PRESSURE AND CONDUCTIVITY

It has been quite firmly established that the freezing point of milk is its most constant property, and in consequence, can be satisfactorily used as a means of detecting watering (19).

In table 6 it is shown that individual samples of widely varying natural acidity are remarkably constant in freezing point. That

all milks from normal animals of a given species should have the same osmotic pressure and consequently the same freezing point is a theory soundly founded. The crystalloidal constituents are believed to pass from the blood by ultrafiltration (20), and as the blood of all individuals of a species has the same osmotic pressure, so should the milk. Any variation in the amount of one crystalloid in milk is found to be compensated by an opposite variation in others. Lactose and chlorides particularly have been found to thus vary inversely (21). A close inverse relation between lactose and chlorine is noted in table 6, which accounts in large measure for the constancy of freezing point, though, of course, high phosphates in the high acid milk are effective in influencing osmotic pressure in so far as these are soluble.

Some years ago conductivity was believed to be a very constant property of milk but it has since been disproved. The ionizable constituents may vary considerably, and it is these that control the passage of electric current. Since the chlorides, of all the ash constituents, are about the most important in affecting conductivity there should be found some relation between this property and chlorine content. This is, indeed, the case, as is shown in the table.

High acid milk is on the whole richer and contains more lactose. It is roughly true also that it contains less chlorine and has a lower conductivity. The approximate reciprocal relation between lactose and conductivity is also shown.

COAGULATION BY RENNET AND ALCOHOL; ALDEHYDE REDUCTASE

Some investigations have pointed to the fact that there is a relation between the chemistry and colloidal properties of milk and its coagulability with rennet (22), with alcohol (23), and the aldehyde reductase reaction (24).

On samples of milk with different acidities the rennet test was applied by adding to 20 cc., 2 cc. of a weak rennet solution and holding at 35° with gentle agitation. Time necessary for the first appearance of flakes was noted.

The alcohol test was made by determining the least amount of 90 per cent (by volume) alcohol necessary to cause the appearance of flakes when added all at once to 10 cc. of milk.

Aldehyde reductase was measured by adding to 10 cc. of milk 1 cc. of Schardinger's formaldehyde methylene blue reagent (25), covering the surface with a layer of toluene, holding at 47-50°, and noting time of complete disappearance of color.

The results in table 7 show no regular relation between acidity and any of these determinations, though perhaps in general the low acid milks seem to show somewhat greater reductase activity. It should be noted in this connection that Burri and

TABLE 7

COW NUMBER	ACIDITY	RENNET; TIME IN SECONDS	CUBIC CENTIMETERS 90 PER CENT ALCOHOL	REDUCTASE TIME;	
				Minutes	Seconds
3	0.225	42	2.0	9	30
19BF	0.207	102	5.5	4	2
20	0.202	49	2.0	13	15
24	0.194	100	6.5	6	15
21	0.192	63	4.0	7	20
16	0 157	150	5.5	5	0
Herd	0.153	67	5.0	7	30
19BH	0.153	200	20.0	2	40
22	0.126	115	8.0	4	0
23	0.121	55	4.1	4	50
18	0.112	107	6.0	4	0

Kürsteiner (26) found that reductase activity was greater in milk with a large proportion of cellular elements, and also that Van Slyke and Baker (27) report a greater content of these cellular elements in low acid milk.

There is seen, however, a rather close relation between the speed of rennet reaction and the amount of alcohol necessary for precipitation. These phenomena do not, apparently, depend upon acidity but more likely upon the relationship of the various constituents of milk, similar conditions being favorable to both reactions.

One sample particularly is extreme in this respect—19 BH—requiring an unusual time for coagulation by rennet and also a

large amount of alcohol for precipitation. An analysis made on a sample from the same source but taken at a different time showed the casein to run unusually low and the albumin high. This condition might easily account for the difficulty with which the casein is coagulated by rennet and alcohol. The albumin, acting as a protective colloid, would inhibit the flocculation of casein.

It was pointed out earlier in this paper that concentration of hydrogen ion and acidity by titration vary in the same direction quite regularly. It follows, therefore, that rennet activity here did not seem to be influenced by the former. It is probable, however, that when all other conditions are the same, rennet and alcohol coagulation take place more easily when the acidity is increased. Certain other peculiarities in these samples no doubt influence the coagulation reactions more than hydrogen ion concentration.

SUMMARY AND CONCLUSIONS

Determinations of acidity in milk from a large number of cows have shown variations from 0.086 to 0.229 per cent calculated as lactic acid, and in terms of pH from 6.898 to 6.432.

In general, high acid milk contains more of all the nutrients and is particularly high in phosphates; it has greater food value, therefore, than milk of low acidity.

On account of the fact that it contains a larger proportion of buffer substances, phosphates and casein especially, it would be expected to increase less in hydrogen ion concentration with a given addition of acid or alkali than low acid milk. This was found to be the case. From the point of view of commercial handling of milk this fact is of some importance. High acid milks under the same condition of storage reach the coagulating point later than milk of lower acidity. The following observation illustrates that point: Two samples of fresh milk, one with natural acidity of 0.144 per cent and the other 0.175 per cent were allowed to stand side by side at room temperature. At the end of 9½ hours the first sample coagulated on heating, while the latter did not respond to this test until thirteen hours had elapsed.

Under ordinary conditions of handling, the carbon dioxide varied but little in the different samples. The low acid milk contained, perhaps, a little more. It was calculated that enough free carbon dioxide is usually present to account for the acidity equivalent to 0.01 to 0.02 per cent lactic acid.

Between citric acid and acidity there was found no regular variation. But from experiment it was calculated that acid citrates might account for 0.01 per cent acidity in all samples.

High acid milk contained somewhat more casein yet there was not enough difference to account for more than a small part of the difference in acidity between the high and low acid samples. It was concluded that the acidity due to casein is 0.05 to 0.08 per cent.

The albumin accounts regularly for a little less than 0.01 per cent.

The difference between the total acidity and that due to the sum of the factors just enumerated is attributed to phosphates. Practically the entire difference in acidity between the various samples was shown to be due to this constituent.

The hypothesis is advanced that a condition of equilibrium exists between certain of the milk constituents, particularly citric acid, phosphoric acid, casein, and the bases, and that the acidity due to any one of these depends upon its relation to the others. It is this equilibrium which fixes the hydrogen ion concentration; and a change in the proportion of a constituent or ion will result in a shift in the equilibrium and a change in the influence which each has upon the acidity. The calculations just made, therefore, should not be considered arbitrarily. They represent merely the result of the necessity for using alkali to bring the hydrogen ion concentration of each constituent from that of milk to that point at which the phenol phthalein end-point happens to be.

The decrease in acidity of milk on dilution is due to the hydrolysis of both phosphates and caseinates.

The osmotic pressure of milks of varying degrees of acidity was found to be the same. In low acid milks where lactose is low, the chlorides particularly were high. Thus there is a reciprocity which accounts for the constancy of osmotic pressure.

A fairly close relation between chlorine and conductivity was found as might be expected, though, of course, other salt constituents may conduct the current as well. There is, consequently, an approximate relation between acidity and conductivity, milk with low acidity running high in conductivity.

There was no relation between natural acidity (or pH) and coagulability with rennet and with alcohol. These properties were found, however, to run hand in hand, both probably depending upon certain relations between the constituents in milk which are independent of acidity.

The aldehyde reductase reaction is somewhat more rapid in low acid milks but the relation is only general and is believed to be secondary.

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FACTS ABOUT CARBONATED BUTTER

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Within the last two years numerous inquiries have come to me regarding the merits of carbonated butter. Some of the inquiries pointed out that the promoters of carbonating butter referred to some of my publications as substantiating their sweeping claims of the virtues of carbonated butter. Voluminous advertising propaganda is now conducted in several consuming centers, belaboring the trade and advising the public as to the all-embracing benefits of carbonated butter and the "terrible shortcomings" of butter made in the presence of air. The situation has reached a point where it seems advisable to offer a brief and unbiased statement of the now-known facts of the possibilities and limitations of the process of carbonating butter.

WHAT IS CARBONATED BUTTER?

The so-called carbonating of butter consists of churning the cream and working the butter in an atmosphere of carbon dioxide gas. The churn is loaded with the cream. The gas then is introduced at the bottom of the churn at the end opposite the air vent. The air vent is left open permitting the air to escape while the gas enters. When the gas begins to come out of the air vent, the vent is closed. The cream is then churned and the resulting butter is washed in the usual manner and with the churn open. After the salt has been added the churn is closed, is again filled with the gas, and the working is completed. In the case of the Simplex churn and similar types where the working must be done with the churn open, the butter is worked in the presence of air and the carbon dioxide treatment is confined to the churning operation only.

In short, then, the churn is filled with the carbon dioxide gas. This is all there is to the carbonating of butter, no more, no less. After churning and working, the butter is removed from the

churn and is packed in tubs or boxes in the usual manner and exposed to the air as always. In the earlier stages of the promotion of carbonating butter, it was claimed also that by carbonating his butter the buttermaker could do away with some of the standard and approved processes of manufacture, such as standardization of cream for acidity, pasteurization, the use of starter, etc. A few trial churnings made to determine the dependability of these unusual claims gave such disappointing, though obvious results, that these all-sweeping claims were promptly withdrawn. It should be clear from this, therefore, that the carbonating of butter is a treatment in addition to the generally approved method of butter manufacture. It eliminates or displaces nothing in the normal process of manufacture; it therefore economizes nothing, neither fuel nor labor; if done at all it must be a treatment additional to what we are now doing. It means an added expense of manufacture.

WHAT ARE THE CLAIMS MADE FOR CARBONATED BUTTER?

The following are some of the more outstanding claims made by the promoters of carbonating butter:

1. Conservation of vitamins in butter.
2. Making a mechanically pure butter by keeping dust-laden air out of it.
3. Destruction of bacteria.
4. Improved flavor.
5. Greater keeping quality.

In advancing these claims reference is made by their authors to the name and works of a long list of scientific authorities. Isolated paragraphs from some of these works are quoted and by inference or otherwise it is made to appear that these authorities experimented with butter and that they did find:

That uncarbonated butter loses a large portion of its vitamin strength while carbonated butter conserves it.

That the atmospheric air pollutes the butter with the dust and filth contained in this air, while carbonated butter is free from all these impurities.

That uncarbonated butter is teeming with a great multitude of undesirable bacteria, dangerous to health and disastrous to the quality of the butter, while the carbonating eliminates this danger by destroying the germ life.

That the air in uncarbonated butter inevitably produces rapid oxidation which deteriorates the butter and makes it unfit for consumption, while carbonated butter is free from the danger of such oxidation.

That the carbonated butter has a better flavor and possesses greater keeping quality than uncarbonated butter.

These contentions and inferences, though bulging with monstrous inaccuracies to the point of collapse, sound plausible to the unsuspecting consumer who pays the bill and who wants and asks for butter that is pure and of good quality and, therefore, harmless, safe, and wholesome. Hence these claims furnish advertising thunder and sales talk of a type that proves effective, at least while the camouflage remains intact.

The fact, however, is that these claims are not based on scientific experimentations at all. They are mere theories and hypothetical conclusions. They are the product of an ingenious imagination and do not deserve serious consideration as far as scientific argument is concerned. Their relation to the welfare of the industry, however, compels unbiased and fearless exposure. It is for this reason that each of the above claims will be discussed by itself in the following brief paragraphs:

DOES CARBONATING CONSERVE VITAMINS IN BUTTER?

The contention of the promoters of carbonating is that butter made without carbon dioxide treatment is low in vitamin properties. The argument is that the free oxygen contained in the air with which the cream and butter come in contact during churning and working causes oxidation which in turn destroys a portion of the vitamin properties of the butter. On the other hand, when churning and working in carbon dioxide gas this air is not present, hence oxidation does not take place and the vitamins retain their full strength.

There is no experiment on record, neither in this country nor abroad, to show that the relative vitamin strength of carbonated

and uncarbonated butter has ever been subjected to study. The above claim is purely hypothetical, it is an assumption with no facts to support it whatsoever, but there is an abundance of experimental evidence available showing that the maker of this assumption was ill-advised and that the hypothesis is entirely erroneous.

According to the present status of the newer knowledge of nutrition, the vitamin content of butter is confined very largely to vitamin A (fat soluble A). Other vitamins, if present at all, are there in such small amounts as to be of no consequence. The nutrition experts who discovered vitamin A and experimentally studied its effect on different animals, used butter from which they derived the milk fat that furnished the vitamin A. That butter was made in the ordinary way; that is, in the presence of atmospheric air and not in an atmosphere of carbon dioxide. The great discoveries they made and the wonderful results they obtained in their feeding experiments suggest that vitamin A had lost none of its vitality in spite of the presence of air.

Later they were interested to find out to what extent the deterioration of butter and butter oil would have to progress in order to diminish the activity of vitamin A. Butter was melted and the oil boiled in the air with live steam for several hours without injury, alkalies were added to the oil in the presence of air, enough to make a cake of soap out of it, and still the vitamin remained intact. It was only when butter was exposed to air and light and heat to such an extent and for so long a time that it became bleached and tallowy and utterly unfit for consumption by man or beast that the vitamin strength suffered a decline.

The dominating and conclusive fact here is that the eminent nutrition experts who discovered and experimented with the vitamins contained in butter state unreservedly and unconditionally that the only cases where the milk fat derived from butter had depreciated in its vitamin content were those where it had been the express purpose of the experiment to determine how great an extent of deterioration of butter was necessary before the butter showed a decline in its vitamin strength. And they further state that their feeding experiments demonstrated that there was no

decrease in the vitamin properties of butter resulting from the process of manufacture nor from ordinary commercial cold storage.

These facts are fully borne out also by experiments with ice cream, conducted by the National Association of Ice Cream Manufacturers, under the direct supervision of Dr. Arthur H. Smith, and published in a "Report of an investigation into the effect of freezing ice cream in an atmosphere of carbon dioxide." Dr. Smith summarizes his feeding experiments as follows:

> The experimental findings discussed above represent the results of studies on rats and guinea-pigs extending from May 16, 1922, to September 21, 1922. They indicate that the vitamin A in 1 gram of pasteurized ice cream mixture is the minimal amount which will promote normal growth in white rats fed on an otherwise adequate diet, whether the mixture is fed as such, frozen in air or in an atmosphere of carbon dioxide.
>
> When the ice cream mixture furnishes the sole source of vitamin B for rats on an otherwise adequate diet, 7.7 grams equivalent to 15 grams of milk was required for normal growth. Freezing the mixture in air or in an atmosphere of CO_2 had no effect on the water-soluble vitamin in the mixture.
>
> Guinea-pigs on a scurvy-producing diet were not protected against the disease by the maximal amount of ice cream they could be forced to eat, whether it was frozen in the air or in an atmosphere of CO_2.
>
> Conclusions: From the data at hand we are forced to conclude that there is no evidence supporting the contention that freezing ice cream in an atmosphere of carbon dioxide preserves the vitamins which are present in the unfrozen pasteurized mixture to a greater extent than freezing the ice cream in air.

And so in the case of butter, the vitamins are neither made nor accelerated, nor injured, nor destroyed by any treatment to which the cream or butter may be subjected in the usual operation of the churn, whether this treatment be in air on in an atmosphere of carbon dioxide. Nor does churning and working in air cause any decline in the vitamin strength in butter in commercial cold storage, or under other storage conditions to which butter may be expected to be exposed during the normal passage from creamery to consumer.

This, then, explodes the vitamin bubble of carbonated butter, a beautiful bubble except for the intended and vicious deception of the consuming public regarding the vitamin-superiority of carbonated butter. It does not exist.

IS CARBONATED BUTTER MECHANICALLY PURER THAN NON-CARBONATED BUTTER?

The contention of the promoters of carbonated butter is that the air is very impure, that it is laden with dust and similar impurities. Therefore, so they say, butter made from cream churned in the presence of air is very impure. Carbon dioxide, on the other hand, they claim to be immaculately pure, hence butter churned and worked in an atmosphere of this gas is exceptionally free from impurities.

Here again imagination plays a dominant part in the development of this accommodating hypothesis. There are no data on record that show that butter churned and worked in air contains a larger percentage of these mechanical impurities than butter churned and worked in an atmosphere of carbon dioxide.

Little tangible information is available regarding the relative purity of creamery air and carbon dioxide. However, it is safe to say that the air in the churn at the time the churn is loaded with the cream is relatively pure, the fact is it is washed air. In every well-regulated creamery the churn is steamed out or rinsed out with hot water, and then rinsed with cold water so as to close the pores of the wood and to prevent the butter from sticking to it. The buttermaker would not do without this rinsing because of the mechanical difficulties of the butter sticking to the wood and the obvious injury to the body of the butter, hence rinsing out the churn is as regular a performance as the churning itself. This rinsing is performed by revolving the churn for a few minutes with the water in it. In this operation the air is thoroughly mixed with the water and it would seem reasonable to conclude that the amount of mechanical impurities left in it would be negligible.

Again, after a few minutes of churning the vent is opened in order to release the pressure generated by the liberation of the gases in the cream. In the case of carbon dioxide instead of generating pressure in the churn a partial vacuum is formed due to the action of the CO_2 and when the churn vent or door is opened to release this vacuum the outside air rushes in with great force, carrying into the churn all that dust that is claimed to be in the air.

Also it does seem a little late in the process to try protecting the cream and butter from the mechanical impurities in the air, after the milk is drawn into an open pail in the form of fine streams from the teats and with enough force to whip an inch or more of foam up in the pail. In the centrifugal separator again, air is added and from there on the cream is exposed to air continuously while on the farm, in transit, and in the creamery until it reaches the "saving" atmosphere of carbon dioxide in the churn. When the butter is removed from the churn it is exposed to the air again during packing, printing, wrapping, and more or less until it is consumed.

The National Association of Ice Cream Manufacturers included in its extensive investigation hereinbefore quoted, a study of the dust content of normal and carbonated ice cream. Dr. C. E. A. Winslow, under whose immediate direction this particular phase of the investigation was performed, reports as follows:

> The dust content of the ice cream is not appreciably affected by the Heath System (meaning the carbonating process); no influence of this kind could reasonably be expected since the ice cream contains several thousand dust particles per gram while the air which is mixed with it in the proportion of about one cubic centimeter of air per gram of ice cream contains only between one and two dust particles per cubic centimeter. Comparison of the air in the freezers before the mix was admitted shows that as a matter of fact the air to be mixed with the ice cream in the Heath Process (meaning the carbonating process) actually contained rather more dust particles than were present in the air of the freezer when operated under ordinary conditions.

The above facts and findings are ample to demonstrate the perfect absurdity and pure nonsense of this so loudly-heralded superior purity of carbonated butter.

DOES CARBONATING OF BUTTER DESTROY UNDESIRABLE BACTERIA?

The claim here is that carbon dioxide gas is destructive to bacteria, that carbonating greatly reduces the numerical count and that by so doing the butter is rendered safe from the standpoint of its possible infection with germs of human diseases and that the destruction of other bacteria makes for butter of better keeping quality.

It should be understood here that with reference to the presence or absence of air there are two separate groups of bacteria. To one group belong all those species of microorganisms that must have air in order to live and thrive. To the second group belong the species of germ life that either cannot live or do not thrive in the presence of air, but thrive luxuriantly in the absence of air or in the presence of an inert gas. It is a fact, scientifically well known, that many of the most objectionable and harmful bacteria, such as bacteria that cause putrefaction and the formation of ptomains, or decompose cream with the production of butyric acid, require the absence of air.

That the carbonating of butter does not hinder bacterial deterioration and spoiling of butter was indicated convincingly in split experimental churnings made on a commercial scale in which one-half of the cream was pasteurized and churned in the normal way and the other half was not pasteurized but was given carbon dioxide treatment in the churn. After twelve weeks storage the carbonated butter had become strongly rancid and the score had dropped from 89 points when fresh to 83 points at the end of the twelve weeks, while the uncarbonated butter from the check churning, the cream of which was pasteurized, retained its score of 89 points.

None of our experiments included a study of the effect of carbonating on germs of human diseases. If such germs accidentally were present in the original cream they would not survive the pasteurizing process, which is effectively controlled by a complete system of automatic temperature controllers and recorders.

However, Prucha, Brannon, and Ambrose, who conducted experiments at the University of Illinois under the direction of

Dr. H. A. Ruehe, reported that cultures of Bacillus typhosus inoculated into milk that was subsequently subjected to from 10 to 30 pounds of pressure of carbon dioxide were not destroyed. On the contrary, in four days under 20 pounds of pressure of carbon dioxide gas these bacilli increased from 47,000,000 to 153,000,000 per cubic centimeter of milk.

These investigators further report that

> In comparing the bacterial counts in the plain and in the carbonated ice cream, we are forced to the conclusion that the carbon dioxide gas did not cause any appreciable reduction in the number of bacteria in the carbonated ice cream. If it did destroy any bacteria the number was so small that our method did not detect it. One of the lots of ice cream was kept in the hardening room for six months. Even after this long period of time the carbonated ice cream had just as many bacteria as the plain ice cream.

Prof. Leo F. Rettger of Yale University, who studied "The influence of carbon dioxide on bacteria" for the National Association of Ice Cream Manufacturers, states, "The results obtained in the present investigation are in perfect harmony with the observations of Prucha and his associates in the University of Illinois."

So here again, as in the case of the previously discussed contentions, the claimed miraculous benefit of carbonating disappears in the face of actual scientific facts. Carbonating cannot be depended upon as a means of destroying harmful or injurious bacteria that may be present in the cream and of rendering such cream or the butter made from it safe for human consumption. Nor can carbonating be relied upon to destroy bacteria that are harmful to the flavor and keeping quality of the butter. Carbonating is incapable of taking the place of pasteurization. Without pasteurization carbonated butter becomes rancid and develops other objectionable bacterial flavor defects quickly and intensely, as is the case with uncarbonated butter made from unpasteurized cream. Carbonating does not improve the bacterial status of butter.

DOES CARBONATING IMPROVE THE FLAVOR OF BUTTER?

The contention here is that carbonated butter, being "purer" than ordinary butter, has a cleaner flavor, and because of the flavor-accentuating tendency of carbon dioxide, has a more pronounced pleasing flavor.

In our experiments in which churnings from the same vat were used for both treated and untreated butter, and in which the judges had no knowledge of the treatment that had been given the cream and the butter in the churn, the scores showed no difference between carbonated and ordinary butter. In split churnings where the untreated butter scored 91 points, the carbonated butter also scored 91 points, except in the case of butter where the carbonating was done in the place of our regular method of neutralization and pasteurization instead of in addition to our regular method, and in this case the carbonated butter scored one point lower than the untreated butter.

The above represents results of experiments carried out with exactness. The purpose was to secure unbiased facts. A vast number of other creameries could be cited to whom the attractive and convincing contentions of the promoters of the carbonating process appealed sufficiently to give the process a try-out, but who soon were forced to realize that the much advertised superiority of carbonated butter did not materialize; they abandoned the manufacture of carbonated butter because the product failed to make good.

And so once again the conclusion is compelling that a vital claim for carbonated butter falls by the way side. Carbonating does not improve the flavor of butter in the sense of increasing its market value. It is possible that the butter at the churn may possess a slightly accentuated snappiness of flavor that pleases the palate. If this is the case, the favorable effect is of too short duration to be of commercial value, as clearly indicated above by the agreement in score between carbonated and uncarbonated butter.

DOES CARBONATING IMPROVE THE KEEPING QUALITY OF BUTTER?

The contention of the promoters of carbonating here is that because carbonating "reduces the bacterial count" and because it "prevents" oxidation, the factors that are responsible for butter deterioration are largely eliminated, hence carbonated butter keeps better.

It has already been shown under the caption "Does Carbonating of butter destroy undesirable bacteria?" that the absence of air brings about a condition favorable for some of the most objectionable groups of bacteria such as those whose activity means putrefaction and other harmful decomposition.

As previously stated, our own experiments demonstrated that carbonated butter that is not made from properly pasteurized cream has no keeping quality at all. The carbonated butter became rancid and dropped from 6 to 7½ points in twelve weeks, while the untreated butter made in the regular way and kept under the same conditions showed the usual good keeping quality. This merely emphasizes the fact that carbonating cannot be relied upon to make butter keep as far as prevention of bacterial deterioration is concerned.

Another important agency that influences the keeping quality of butter is oxidation. It is well known and fully recognized by dairy scientists that oxidation is one of the outstanding causes of butter deterioration. Again wholly disregarding scientific facts, the promoters of carbonating proclaimed that churning in an atmosphere of carbon dioxide would eliminate deteriorating oxidation in butter.

If the cream were pasteurized, churned, and the butter washed, worked, packed, and hermetically sealed in an atmosphere of carbon dioxide, there might be some real merit to carbonating butter from the standpoint of eliminating the oxidizing action of the air. But as it is, the carbonated butter is laboriously manipulated in air after it leaves the churn and no attempt whatsoever is made to prevent the carbon dioxide from escaping and the air from entering in its place. The butter is taken out of the churn, is packed into tubs or cubes, tamping vigorously each handful

as it is thrown into these receptacles, and later on much of this butter is cut up into prints with still more surface exposed to the air. Obviously, much of the carbon dioxide is thus pounded out and into its place much air is pounded into the butter.

It stands to reason, therefore, that the supposed protection by carbon dioxide is very largely forfeited and the so-called carbonated butter has sufficient contact with air to make possible oxidation through air.

However, air is only one of the many factors that under certain conditions may assist in deteriorating butter through oxidation. The newer knowledge of butter deterioration recognizes that in the problem of preventing chemical deterioration in commercial butter the air is sufficiently eliminated in the regular method of manufacture and packing to constitute a negligible factor as compared with other and more important factors and combinations of factors, such as acidity of cream, and the presence of metals and metallic salts and oxides. If the process of manufacture is so regulated that the acidity is standardized to the proper point, and the cream and butter are protected against excessive exposure to metals that are active oxygen carriers and catalyzers, there is very little danger from oxidation and other chemical action that leads to the deterioration of the butter with age. If these factors are not taken care of, then mere churning of the butter in an atmosphere of carbon dioxide is of no avail and means nothing more than wasting gas and time.

Actual experiments in which the keeping quality of carbonated butter was compared with that of uncarbonated butter are very limited. What data we have show that if butter is made right as to acidity, pasteurization, and protection against the action of metals, it will have equally good keeping quality whether carbonated or not. If the above factors are neglected or ignored altogether the butter will not keep, it will deteriorate rapidly, whether carbonated or not.

SUMMARY

1. The vitamins in ordinary butter are not diminished by the regular processes of manufacture, nor are they weakened as the result of commercial cold storage.

The contention that carbonated butter is richer in vitamins than butter made in the regular standard way has no foundation whatsoever. It is a myth.

2. There is no evidence to show that butter churned and worked in air contains more mechanical impurities than butter churned and worked in an atmosphere of carbon dioxide.

The available facts indicate that the contention that the mechanical purity of carbonated butter is superior to that of uncarbonated butter is purely hypothetical and completely devoid of scientific facts.

3. Carbonating cannot be relied upon as a means of destroying harmful and injurious bacteria that may be present in the cream and rendering such cream or the butter made from it safe for human consumption.

Carbonating cannot be relied upon to destroy bacteria that may be present in the cream and that are harmful to the flavor and keeping quality of the resulting butter.

Carbonated butter develops the usual bacterial flavor defects if made from unpasteurized cream.

4. Carbonating does not improve the flavor and market value of butter. It may accentuate the flavor slightly but the effect is of short duration only and not sufficiently recognizable to affect its market value.

5. Carbonated butter keeps no better than butter not carbonated. If the method of manufacture as relating to neutralization, pasteurization, and protection from metals and metallic salts is right, the keeping quality of carbonated and uncarbonated butter is equally good. In the absence of these standard and approved methods carbonated butter will not keep.

6. These facts show conclusively that the pretended superiority of carbonated butter does not exist.

SWEETENED CONDENSED MILK

II. A COMPARATIVE STUDY OF METHODS FOR DETERMINING TOTAL SOLIDS[1]

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Sweetened condensed milk on account of its high sucrose content is generally considered one of the most difficult dairy products to test for total solids. In the past the official procedure of the Association of Official Agricultural Chemists has usually been employed, while more recently the Mojonnier method has come into common use.

So far, however, little study has been made as to the relative accuracy of the Mojonnier method as compared with the official. The only reference found in scientific literature is by Mojonnier and Troy (Technical Control of Dairy Products). One batch of condensed milk was tested by six operators using the Mojonnier method. The results obtained by these men were then checked against the official method as applied by still another operator. While their results seem to indicate close agreement between the official and the Mojonnier, the data is rather too meagre to allow drawing conclusions.

Furthermore, both these methods, while perhaps the best available at present, have certain disadvantages, which limit their use in many instances. The official method, although undoubtedly accurate and reliable, is laborious and time consuming, requiring from six to eight hours for completion. The Mojonnier method on the other hand, while rapid, necessitates

[1] The work reported in this article was done in the Laboratory of Chemistry, Cornell University.

the use of expensive equipment which frequently is beyond the financial means of a laboratory or commercial firm.

In view of these facts it was thought desirable to run a series of trials in order to check the Mojonnier method against the official, as well as to attempt to find a simple and accurate method which might possess advantages that these do not have.

EXPERIMENTAL WORK

Twenty samples of condensed milk were analysed by three methods: (1) the official, (2) the Mojonnier, and (3) a modified method suggested by the authors.

The procedure of each method was as follows:

1. *Official method.* The Association of Official Agricultural Chemists method as described in Methods of Analysis of the Association of Official Agricultural Chemists, page 231, was followed except that 20 grams of condensed milk were made up to 100 cc. with redistilled water instead of 100 grams to 500 cc. as outlined. Clean sand was added to the dishes to facilitate drying.

2. *Mojonnier method.* The procedure for determining total solids in sweetened condensed milk as described in Technical Control of Dairy Products by Mojonnier and Troy, page 125, was followed exactly.

The alternative is given of drying the samples for only twenty minutes and applying correction by deducting 0.3 from the final per cent of total solids or of drying the sample for ninety minutes. In these trials, samples were dried for both twenty minutes and ninety minutes for comparison.

3. *Modified method.* Twenty-five hundredths to 0.35 gram portions of thoroughly mixed sample were weighed into previously dried and tared aluminum dishes. Two cubic centimeters of hot distilled water was added and after mixing, the dishes were placed on an electric hot plate kept at about 180°C. and the solution carefully evaporated until first traces of brown appeared. Drying was then continued in an oven at the temperature of boiling water until constant weight was reached.

The dishes used in this test were ordinary flat-bottomed aluminum dishes about 5 cm. in diameter. Empty dishes were dried for ten minutes in the water oven and then cooled for a similar period in an ordinary calcium chloride desiccator; they were always kept covered while weighing.

The percentages of total solids obtained by each of the three methods are reported in table 1. In interpreting and analysing the data the nature of the product tested should always be considered. Containing from 70 to 74 per cent solids in which 40 to 45 per cent is sucrose, it is practically impossible to obtain results checking as closely as some other products such as whole milk, evaporated milk and ice cream. Bearing this in mind the three

TABLE 1

Percentage of solids in samples of condensed milk according to the three methods studied

SAMPLE NUMBER	OFFICIAL METHOD	MODIFIED METHOD	MOJONNIER	
			At 20 minutes	At 90 minutes
1a	73.09	73.35	73.63	73.64
1b	73.15	73.49	73.74	73 64
2a	72.32	72.96	72.95	73.03
2b	72.40	73.02	72.97	72.97
3a	72.86	72.87	73.20	73.15
3b	72.72	72.95	73.22	73.20
4a	71.05	71.97	71.54	71.44
4b	71.11	71 92	71.50	71.39
5a	72.73	73.67	73.35	73.35
5b	72.72	73.68	73.41	73.43
6a	71.90	72.21	72.95	72.94
6b	71.92	72.13	72.90	72.96
7a	73.47	73.45	74.05	73.93
7b	73.39	73.46	74.06	74.10
8a	72.64	72.80	72.99	72.91
8b	72.56	72.96	73.06	72 99
8c	72.72	73.31	72.93	72.99
8d	72.43	73.19	72.91	72.80
9a	71.82	72.33	72.56	72.72
9b	71.73	72.43	72.49	72.49

tests show reasonably close correlation in results. In all instances except one, the official method gave lower results than the Mojonnier or the modified. It is further interesting and significant that in more than two-thirds of the cases the Mojonnier method was the highest of all, while the modified test gave results usually between the official and the Mojonnier.

A better analysis can perhaps be made from table 2 in which are tabulated the differences obtained in the three methods. Com-

pared with the official method the Mojonnier invariably gave higher results. On the 20 samples the average was 0.57 per cent higher. In the case of the modified method the average was 0.47 per cent above the official.

TABLE 2

Variation in percentage of solids in condensed milk as obtained by the three methods studied

SAMPLE NUMBER	MODIFIED FROM OFFICIAL	MOJONNIER FROM OFFICIAL	
		At 20 minutes	At 90 minutes
1a	+0.26	+0.54	+0.55
1b	+0.34	+0.59	+0.49
2a	+0.64	+0.63	+0.71
2b	+0.62	+0.57	+0.57
3a	+0.01	+0 34	+0 29
3b	+0 23	+0.50	+0.48
4a	+0.92	+0.49	+0.39
4b	+0.81	+0.39	+0.28
5a	+0.94	+0 62	+0.62
5b	+0.96	+0.69	+0.71
6a	+0.31	+1.05	+1.04
6b	+0.21	+0.98	+1.04
7a	−0.02	+0.58	+0.46
7b	+0.07	+0.67	+0.71
8a	+0.16	+0.35	+0.27
8b	+0.40	+0.50	+0.43
8c	+0.59	+0.21	+0.27
8d	+0.76	+0.48	+0 37
9a	+0.51	+0.74	+0.90
9b	+0.70	+0.76	+0.76
Average variation	0.47	0.57	0.57
	55 per cent within 0.5 per cent of official	30 per cent within 0.5 per cent of official	30 per cent within 0.5 per cent of official
	—	—	—
	80 per cent within 0.75 per cent of official	85 per cent within 0.75 per cent of official	80 per cent within 0.75 per cent of official

Taking the official method as the standard for comparison the modified method here proposed gives more favorable results than the Mojonnier. It furthermore is simpler and more rapid

than the official. The equipment needed is inexpensive and frequently on hand in the laboratory.

In order to determine the average time for samples in the modified test to reach constant weight, careful record as to time of drying was kept in the case of 14 samples. The dishes containing the condensed milk solids were first weighed at the end of two hours drying in the oven and then again at intervals of 30 minutes until constant weight was reached.

TABLE 3

Time required for solids in condensed milk to reach constant weight in modified test

SAMPLE NUMBER	PERCENTAGE OF MOISTURE LOST AT VARIOUS PERIODS OF DRYING IN WATER OVEN				
	0 to 2 hours	2 to 2½ hours	2½ to 3 hours	3 to 3½ hours	3½ to 4 hours
1a	26.65	0	0	0	0
1b	26.25	0.10	0.13	0.02	0.01
2a	27.04	0	0	0	0
2b	26.93	0.05	0	0	0
3a	27.03	0.10	0	0	0
3b	27.05	0	0	0	0
4a	27.87	0.12	0.04	0	0
4b	27.69	0.26	0.13	0	0
5a	26.33	0	0	0	0
5b	26.03	0.21	0.08	0	0
6a	26.50	0.86	0.42	0.01	0
8c	26.69	0	0	0	0
8d	26.64	0.17	0	0	0
9a	26.76	0.59	0.29	0.03	0

Results as given in table 3 indicate that while in the majority of cases three hours is sufficient time to reach constant weight, there are occasional samples which require a longer period. Such factors as size of sample and humidity of the air materially affect the rate of drying. On humid days great care must be exercised to weigh and handle dishes quickly in order to prevent moisture being absorbed from the air. All factors considered, it is best, therefore, to dry the samples for three and a half hours, after which one can be reasonably certain that all moisture has been removed.

SUMMARY AND CONCLUSIONS

1. Twenty samples of condensed milk were tested for total solids by the official, the Mojonnier and a modified method suggested by the authors.

2. The Mojonnier method, invariably gave higher results than the official; in 20 samples the average difference was 0.57 per cent.

3. In the Mojonnier method the correction of 0.3 per cent applied at the end of twenty minutes drying in the oven checked closely with the final results at ninety minutes.

4. The modified method also gave somewhat higher results than the official; the average of 20 samples was 0.47 per cent above.

5. In more than two-thirds of the cases, the Mojonnier test was the highest of all, while the modified method usually gave results between the official and the Mojonnier.

6. The time required for 14 samples to reach constant weight in the modified method was between three and three and a half hours, while in the official method it required from five to six hours.

7. The modified method recommends itself as simple and economical for the determination of total solids, and as reliable as the Mojonnier.

THE DISPOSAL OF DAIRY WASTES[1]

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The dairy industry is one which is very widely distributed, because the nature of the raw material limits the time which may elapse between production and consumption. To make this time as short as possible, long-distance transportation of raw milk is not usually practised and therefore local means must be provided for its reception and rapid distribution. Accordingly, scattered over the country are many small dairy plants as well as numerous ones of considerable size. These may be merely receiving or skimming stations, where the character of the milk is not greatly changed; or, on the other hand, they may be creameries, condenseries, cheese factories, butter factories, milk-sugar factories or casein plants, where the raw milk is converted into other products.

When these plants are situated near a city with sanitary sewers, or when large water courses are available to receive it, no difficulty has arisen regarding the disposal of milk waste. But where no sewers are available and a ditch or small stream must receive the waste, nuisances have arisen which, in dry summer weather particularly, have been extremely objectionable.

Several such nuisances having arisen in Maryland, Mr. Abel Wolman, Chief of the Bureau of Sanitary Engineering of the State Department of Health, presented the problem to the Bureau of Chemistry and requested its solution. He suggested that it might be solved by accurately controlling the pH value of the waste. Acknowledgment is hereby made of his suggestions and criticisms. The ultimate solution of the problem was made

[1] A dissertation presented by the author in partial fulfilment of the requirements for the degree of Doctor of Science in Hygiene in the School of Hygiene and Public Health of the Johns Hopkins University.

possible by Dr. W. W. Randall, Chief of the Bureau of Chemistry of the same Department, who so arranged the routine work of the laboratory that the necessary time could be given to this research. Grateful acknowledgment is made of his interest and encouragement at all times.

The disposal of creamery wastes has been the subject of many investigations both in this country and abroad. These have generally been concerned with the wastes from large plants where certain devices, commonly used in sewage purification, have been utilized. Until 1920 this method had not proven satisfactory, but with specially constructed tanks, filters, etc.,—such as have been recommended by Hommon in Public Health Bulletin No. 109(1), —the results obtained were satisfactory enough to demonstrate that the method could be applied, perhaps with modifications, to other types of dairy wastes than had been studied in that investigation.

While it is possible that this method is proving satisfactory for the large plants, it is too expensive and involved to be practicable for small plants or receiving stations. Yet the waste from these and also from skimming stations, even though comparatively small in amount, has given rise to considerable complaint.

This study was undertaken in the hope of finding a simple and easily applied method of abating this nuisance.

The total solids in milk average about 12.9 per cent: fat, 4 per cent; proteins, 2.8 per cent; lactose, 4.75 per cent(3). Lactose and milk fat are fairly stable substances, but proteins as a class are unstable and very readily undergo decomposition. On the assumption that the nuisance was caused by the decomposition of the proteid material, the problem became one of the separation and disposal of protein, with a subsequent study of the relative stability values of the raw and treated waste.

Casein constitutes 80 per cent of the total proteins in milk, therefore conditions were sought which would best serve to remove the casein. No particular attention was given to the other proteins, although it was realized that the fat would also be carried down by the casein during sedimentation, leaving only the lactose and minute amounts of albumin and globulin in the solution.

A review of the literature on proteins and, more particularly, on casein, gave the following reagents as available precipitants:—a saturated solution of sodium chloride, of ammonium sulphate, or of magnesium sulphate, at ordinary temperature; small amounts of alum, of zinc sulphate, or of other metallic salts; calcium chloride and other salts at 34° to 45°; rennet; acids, particularly acetic (2); ferric sulphate (134 grains per gallon); lime to neutrality, with sodium silicate then added(1).

To meet the practical demands of this problem it was required that the precipitating agent be easily available, comparatively inexpensive, and its employment simple in operation. For these reasons the following precipitants were considered: calcium chloride, alum, alum and sulphuric acid, and sulphuric acid alone, with and without the application of heat. It was desired to dispense with filtration, if possible, so that sedimentation or precipitation became of as great importance as flocculation.

After consultation with a dairyman familiar with both large and small plants, it was estimated that the wash-water from a receiving station would contain approximately 0.25 to 0.5 per cent milk. Since even this small amount had caused considerable nuisance, the first experiments were made with these concentrations. In order that the experiments might be as uniform as possible in the beginning, distilled water was used for making the dilutions. Raw milk was supplied in part by the Western Maryland Dairy of Baltimore, and partly by the ordinary laboratory samples which had been received for other analyses. Later, certified milk was purchased from the Walker Gordon Laboratory and used for all determinations. It was thought necessary to use raw milk rather than pasteurized in the experiments for two reasons: first, the difference in bacterial flora would probably cause a difference in the relative stability numbers; and second, owing to pasteurization, the proteins might possibly be in various states of aggregation not found in raw milk, from which the nuisance arose.

A small number of preliminary experiments were set up as follows:

	p.p.m.
(1) 500 cc. ½ per cent milk solution plus calcium chloride	5
(2) 500 cc. ½ per cent milk solution plus calcium chloride	10
(3) 500 cc. ½ per cent milk solution plus calcium chloride	15
(4) 500 cc. ½ per cent milk solution plus calcium chloride	20

These were kept at room temperature (approximately 20°) over night, when no. 3 and no. 4 showed slight flocculation but no sedimentation. Other samples similar to no. 3 and no. 4 were heated to 30°, 40°, and 50°, as well as lowered in temperature to 12°, but a satisfactory floc was not obtained. Further work with calcium chloride was therefore not undertaken.

Casein is an amphoteric electrolyte whose isoelectric point is pH 4.6(4), while the optimum floc formation of alum is at pH 5.5(5). Now in the filtration of domestic sewage, of isoelectric point pH 3.2, it has been found that, when alum is added, the time of filtration is greatly shortened if the isoelectric point is shifted to approximately pH 4.4, the mean of the two isoelectric points(6). Therefore with alum of isoelectric point pH 5.5 and casein of pH 4.6 it might be expected that the best flocculation would occur at pH 5.0 or 5.1.

Accordingly, the following experiments were tried: (I) 500 cc. of ½ per cent milk solution plus alum until pH 5.1 was reached. This required 460 drops of alum, approximately 230 p.p.m. The floc formed almost immediately and settled overnight leaving a clear supernatant liquid. (II) 500 cc. of ½ per cent milk solution plus acid to pH 5.1, plus 10 drops of alum, approximately 5 p.p.m. The floc formed in a few minutes, smaller than in I, but leaving a clear supernatant liquid after standing overnight. Accordingly a more detailed study was made of alum with and without the addition of acid:

0.5 PER CENT MILK SOLUTION	ALUM	pH	FLOC	ACID	pH	B FLOC	SEDIMENTATION OVERNIGHT
cc.	*cc.*			*cc.*			
500	0.5	6.8	—	1	5.2	No floc	None
600	1.0	6.8	—	1	5.2	No floc	None
500	1.5	6.8	—	1	5.1	10 minutes	Good
500	2.0	6.6	—	1	4.8	10 minutes	Good
500	2.5	6.6	—	1	4.6	35 minutes	Good
500	3.0	6.6	—	1	4.4	Overnight	Poor
500	3.5	6.5	—	1	4.4	No floc	None

When an hour had elapsed after the addition of alum and no floc had appeared 1 cc. N/10 acid was added to each sample with the results shown in portion B of the table.

Then the following samples were set up:

0.5 PER CENT MILK SOLUTION	C				SEDIMENTATION OVERNIGHT
	Acid	Alum	pH	Floc	
cc.	cc.	cc.			
500	1	1.0	5.1	Overnight	Poor
500	1	1 5	4.8	10 minutes	Good
500	1	2.0	4.7	10 minutes	Good
500	1	2 5	4.6	2 minutes	Good

At the very beginning of this investigation it had been anticipated that the proper adjustment of the pH value of the milk waste would be the best means of coagulating and precipitating the casein. This seems to be borne out by the above tabulated experiments, which indicate that the alum of itself does not cause or aid flocculation except as it effects the pH value of the solution. Therefore further study with alum was not continued, acid alone being used as the precipitant.

The following samples were then set up:

0.5 PER CENT MILK SOLUTION	ACID	pH	FLOC	SEDIMENTATION OVERNIGHT
cc.	cc.			
500	1.3	5.4	No floc	None
500	1.4	5.3	No floc	None
500	1.5	5.1	11 minutes	Good
500	1.6	4.9	1½ minutes	Good
500	1.7	4.7	2 minutes	Good
500	1.8	4.6	8 minutes	Good
500	2 0	4.4	Overnight	Poor

These results indicate that between pH 5.1 and 4.6 the casein will be precipitated.

All the foregoing pH values may be slightly incorrect owing to a slight acidity in the methyl-red indicator and an incomplete set of buffer solutions for comparison. But as these experiments were merely preliminary ones, it was thought best to include the results, particularly since they indicate the reason acid alone was more extensively studied as the precipitant.

At this point a set of buffer solutions pH 4.2 to pH 6.2 were made, using the phthalate-sodium hydroxide mixtures as given by Clark(7). All the precautions known were taken in the preparation of these, and as the author had formerly made such mixtures which checked with potentiometer measurements, it is believed that these solutions are within the limits of accuracy for readings made with color standards. The alcoholic solution of methyl-red used as indicator was carefully neutralized, and all test tubes cleansed with acid, tap water and distilled water before any readings were made. In each experiment the time of first appearance of floc was noted, as it has been found that "the floc which appears in the shortest time, in any series, is also the one which possesses the qualities of rapid settling and abundance in the highest degree" (5). Accordingly, each floc was numbered, beginning with 1 for that which appeared in the shortest time, and continuing upward for as many different samples in any series as showed any flocculation. This method was adopted rather than the absolute time of flocculation, for, as more experience was obtained in the observation of floc formation, the time became shorter. In the beginning flocculation was observed by tilting the beaker containing the solution so that only a small layer of liquid at the side was observed. Since the observations were made on a table having a black top the floc was easily discerned. When larger volumes were used this method proved impracticable, so an ordinary glass tube, of 4 to 6 mm. bore, was used in which a small portion of the liquid was withdrawn by closing one end of the tube with the forefinger. By carefully wiping off the outside of the tube and looking through a cross-section it was found a simple matter to determine whether or not floc had formed.

The method of procedure was now as follows: 500 cc. of the dilute milk solution, either 0.5 or 0.25 per cent, was poured into an 800-cc. beaker; acid was added from a burette, the time recorded and the solution stirred vigorously. Ten cubic centimeters were at once transferred to a test tube containing a measured quantity of methyl-red indicator. The color produced was then compared with the colors produced by buffer solutions of known pH values plus methyl-red. The color comparisons were made in a simple

comparator, similar to that described by Clark(7) as the "comparator of Hurwitz, Meyer and Ostenberg" (1915). However a paste-board box made by Dr. Randall, was used instead of a block of wood: its construction was simple and in practise it proved satisfactory.[2]

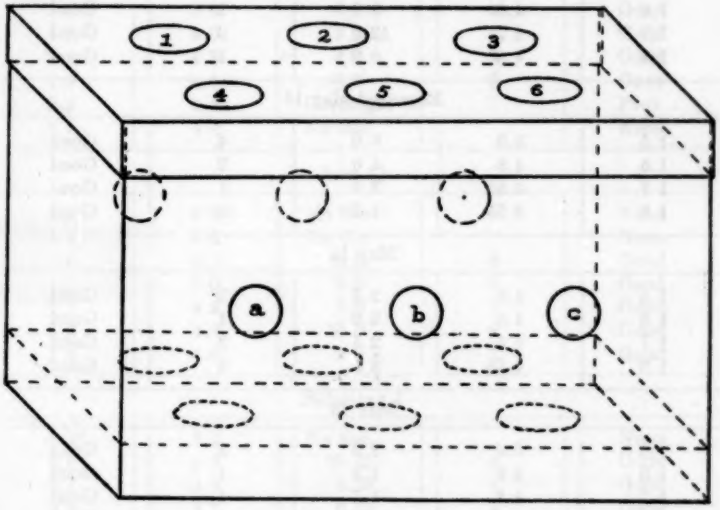

FIG. 1

The following experiments pp. 510–512 were made using 500 cc. of $\frac{1}{2}$ per cent milk solution and $\frac{N}{10}$ sulphuric acid.

[2] The exact size of the box is unimportant, but 6 inches long, 3 inches wide and 3½ inches deep, are good dimensions. In the top of the box are cut six holes, in three pairs, each hole being just large enough to accommodate a test tube. The box is provided with a double bottom, in the upper one of which are cut six holes corresponding to those in the top. In the front and in the back of the box are cut three holes, respectively opposite, through which the light enters and the tubes are viewed. The entire interior is coated with black so that when test tubes are in each hole the only light admitted is through the front and back holes. In holes 1 and 3 tubes of milk solution are placed, in holes 4 and 6 the color standards, in hole 2 a tube of distilled water and in hole 5 a tube of milk solution, plus indicator, whose pH value is desired. The tubes are then viewed through the holes a, b, and c and the standards changed until one of them matches or nearly matches the unknown.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		May 10		
cc.		*minutes*		
1.4	5.1	No floc		None
1.5	4.9	13.5	4	Good
1.6	4.8	9.0	1	Good
1.7	4.7	12.5	3	Good
1.8	4.6	9.0	1	Good
		Repeated May 10		
1.5	5.0	8.0	4	Good
1.6	4.8	4.0	2	Good
1.7	4.65	3.5	1	Good
1.8	4.55	4.5	3	Good
		May 11		
1.5	4.9	2.5	2	Good
1.6	4.8	2.0	1	Good
1.7	4.6	2.5	2	Good
1.8	4.55	3.5	4	Good
		May 18		
1.5	5.0	3.0	3	Good
1.6	4.9	1.5	1	Good
1.7	4.8	1.5	1	Good
1.8	4.6	4.0	4	Good
		May 23		
1.4	5.2	21 0	5	Good
1 5	5.1	10.0	4	Good
1.6	5.0	9.0	3	Good
1.7	4.9	7.0	1	Good
1.8	4.8	8.0	2	Good
1.9	4.7	29.0	6	Good
		May 31		
1.3	5.3	No floc		None
1.4	5.2	No floc		None
1.5	5.1	21.0	5	Good
1.6	5.0	1.75	3	Good
1.7	4.9	1.15	2	Good
1.8	4.9	1.10	1	Good
1.9	4.8	8.10	4	Good
2.0	4.7	38.0	6	Good

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		June 6		
cc.		*minutes*		
1.4	5.2	18.0	6	Good
1.5	5.1	7.5	4	Good
1.6	5.0	3.0	2	Good
1.7	4.9	2.0	1	Good
1.8	4.8	4.0	3	Good
1.9	4.6	9.0	5	Good
2.0	4.5	Overnight	7	Poor
2.1	4.4	No floc		None
		June 11		
1.3	5.2+	No floc		None
1.4	5.2	No floc		None
1.5	5.1	18.0	5	Good
1.6	5.0	9.0	3	Good
1.7	4.9	7.0	1	Good
1.8	4.8	10.0	4	Good
1.9	4.6	7.0	1	Good
		February 4		
1.9*	5.2	No floc		None
2.0	5.0	38.45	5	Good
2.1	4.8	5.20	1	Good
2.2	4.7	6.30	2	Good
2.3	4.6	7.10	3	Good
2.4	4.5	7.45	4	Good
2.5	4.4	No floc		None
		February 7†		
1.8	5.15	180.0	6	Poor
1.9	5.05	3.5	4	Good
2.0	4.8	1.0	1	Good
2.1	4.7	2.5	2	Good
2.2	4.7	3.0	3	Good
2.3	4.6	7.0	5	Good
2.4	4.5	No floc		None
2.5	4.4	No floc		None

* In this and the two following tables 1.25 per cent acid was used.

† In these experiments good sedimentation was obtained, except in the first and last two instances, after five hours, indicating that a detention period of five to six hours might be sufficient.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		February 11		
cc.		minutes		
1.8	5.3	No floc		None
1.9	5.1	6.0	2	Good
2.0	4.9	3.0	1	Good
2.1	4.6	35.0	3	Good
2.2	4.4	42.0	4	Good
2.3	4.4	Overnight	5	Fair

Summary of flocculation scores for ½ per cent solution using volume of 500 cc.

pH.....	4.5	4.55	4.6	4.65	4.7	4.8	4.9	5 0	5.1
Average score.....	4.0	3.5	2.9	2.0	2.0	2.1	1.8	3.3	4.0

The same experiments were tried with 500 cc. of 0.25 per cent milk solution.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		May 16		
cc.		minutes		
0.7	5.2	Overnight	4	Poor
0.8	5.1	78	1	Good
0.9	4.8	78	1	Good
1.0	4.6	198	3	Fair
1.1	4.5	No floc		None
		May 18		
0.7	5.4	No floc		Fair
0.8	5.2	53	3	Good
0.9	5.0	28	1	Good
1.0	4.8	28	1	Good
1.1	4.6	Overnight	4	Good
		May 23		
0.8	5.2	No floc		None
0.9	4.8	29	1	Good
1.0	4.7	40	2	Poor
1.1	4.6	No floc		None

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		May 31		
0.8	5.1	35	3	Overnight
0.9	5.0	31	1	Not observed
1.0	4.8	34	2	Not observed
1.1	4.7	38	4	Not observed
1.2	4.6	46	5	Not observed
		June 6		
0.8	5.2	41	3	Not observed
0.9	5.0	27	1	Not observed
1.0	4.8	30	2	Not observed
1.1	4.7	Overnight	4	Not observed
1.2	4.6	No floc		Not observed
1.3	4.6	No floc		Not observed
		February 11		
1.6*	5.2	No floc		None
1.7	4.7	71	1	Good
1.8	4.5	198	2	Fair
1.9	4.4	198	3	Fair

* In this table and in all that follow 1.25 per cent acid was used.

Summary of flocculation scores for 0.25 per cent solution, using a volume of 500 cc.

pH	4.4	4.5	4.6	4.7	4.8	5.0	5.1	5.2
Average score	3.0	2.0	4.0	2.7	1.4	1.0	2.0	3.3

In an effort to test the "volume effect" upon floc formation the volume of the dilute solution was increased five times, i.e., to 2500 cc. and experiments carried out as before.

0.5 per cent solution, volume 2500 cc.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		June 18		
cc.		minutes		
3.2	5.0	15	3	Good
3.4	5.0	4	1	Good
3.5	4.9	5	2	Good
3.6	4 9	21	4	Good
3.7	4.8	Overnight	5	Good

By this time it was believed that flocculation by means of sulphuric acid was certain, and over a fairly wide range of pH values—5.2 to 4.6. So that it was now thought advisable to make all dilute solutions with tap water, instead of distilled water, more nearly to approach plant conditions, and to determine approximately the amount of acid which a small plant would require.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		January 8		
cc.		*minutes*		
11.0	5.2	No floc		None
11.2	5.1	226.0	10	Good
11.4	5.05	102.0	9	Good
11.6	5.0	52.0	8	Good
11.8	4.9	21.5	7	Good
11.9	4.9	17.0	6	Good
12.0	4.8	10.5	5	Good
12.1	4.7	6.0	3	Good
12.2	4.65	3.0	2	Good
12.3	4.6	2.0	1	Good
12.4	4.5	9.0	4	Good
		Repeated January 8		
11.4	5.1	131.0	9	Good
11.6	5.0	31.0	8	Good
11.8	4.9	29.0	7	Good
11.9	4.9	26.0	6	Good
12.0	4.8	24.0	5	Good
12.1	4.8	19.0	4	Good
12.2	4.7	5.0	2	Good
12.3	4.7	4.0	1	Good
12.4	4.65	5.0	2	Good
12.5	4.5	No floc		None
		Repeated January 8		
11.6	5.0	5.0	6	Good
11.8	4.9	3.5	4	Good
12.0	4.85	2.0	1	Good
12.1	4.8	4.0	5	Good
12.2	4.75	2.5	2	Good
12.3	4.65	3.0	3	Good

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		January 15		
cc.		*minutes*		
10.0	4.95	15.0	5	Good
10.2	4.9	17.5	6	Good
10.4	4.9	8.5	4	Good
10.6	4.85	2.0	1	Good
10.8	4.8	5.0	2	Good
11.0	4.7	5.5	3	Good
		February 4		
9.4	5.2	No floc		None
9.6	5.2	153.0	9	Poor
9.8	5.1	45.0	8	Good
10.0	4.9	1.53	4	Good
10.2	4.85	3.08	5	Good
10.6	4.8	0.91	2	Good
10.8	4.7	4.7	6	Good
11.0	4.6	0.8	1	Good
11.2	4.4	1.08	3	Good
11 4	4.3	30.0	7	Good
		Repeated February 4		
9.8	5.1	48.0	9	Good
10.0	5.0	25.0	8	Good
10 2	4.9	5.66	5	Good
10.4	4.8	5.55	4	Good
10.6	4.7	1.08	1	Good
10.8	4.6	1.25	2	Good
11.0	4.5	6.25	6	Good
11.2	4.45	9.43	7	Good
11.4	4.4	4.33	3	Good
11.6	4.4	92.0	10	Good

Summary of flocculation scores for 0.5 per cent solution, using a volume of 2500 cc.

pH	4.4	4.5	4.6	4.65	4.7	4.75	4.8	4.85	4.9
Average score	3.0	4.0	1.0	2.3	2.0	1.0	3.8	2.3	4.2

0.25 per cent solution, volume 2500 cc.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		February 11		
cc.		*minutes*		
8.0	5.2	103	7	Not observed
8.2	5.0	62	3	Not observed
8.4	4.8	60	2	Not observed
8.6	4.8	55	1	Not observed
8.8	4.7	83	4	Not observed
9.0	4.6	83	5	Not observed
9.2	4.4	87	6	Not observed
9.4	4.3	160	8	Not observed
		February 15		
8.4	5.2	No floc		None
8.6	5.0	41.0	3	Good
8.8	4.8	39.0	2	Good
8.9	4.7	37.0	1	Good
9.0	4.6	42.0	4	Good
9.1	4.4	42.5	5	Good
9.2	4.35	43.0	6	Good
9.3	4.3	74.0	7	Good
		February 18		
8.0	5.0	26	6	Not observed
8.2	4.9	25	5	Not observed
8.3	4.8	18	3	Not observed
8.4	4.7	16	1	Not observed
8.5	4.6	21	4	Not observed
8.6	4.6	17	2	Not observed
8.7	4.6	17	2	Not observed
8.8	4.5	63	7	Not observed
9.0	4.3	66	8	Not observed
		February 21		
6.8	5.0	38	4	Good
7.0	5.0	37	3	Good
7.2	4.9	13	1	Good
7.4	4.7	14	2	Good
7.6	4.6	43	5	Good
7.8	4.6	57	6	Good
8.0	4.4	60	7	Good

Summary of flocculation scores for 0.25 per cent solution, using a volume of 2500 cc.

pH	4.4	4.5	4.6	4.7	4.8	4.9
Average score	5.0	3.2	4.0	2.0	2.0	3.0

1 per cent solution, volume 500 cc.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		February 18		
cc.		*minutes*		
2.2	5 2	No floc		None
2 3	5 1	3.0	6	Good
2.4	5.0	0.93	4	Good
2.5	4.8	0.33	1	Good
2.7	4.6	0 50	2	Good
2 9	4.5	0.61	3	Good
3.1	4.4	1.40	5	Poor
3.3	4.3	No floc		None
		Repeated February 18		
2.3	5.1	No floc		None
2 4	5.0	2.5	7	Good
2.5	4.9	1.03	5	Good
2.6	4.8	0.7	3	Good
2.7	4.7	0.55	2	Good
2.8	4.6	0.41	1	Good
2.9	4.6	0.7	4	Good
3.0	4.6	2.0	6	Poor
3.1	4 5	60.0	8	Poor
3.2	4.4	No floc		None
		February 21		
1.8	5.1	No floc		None
2.0	4.9	1.26	4	Good
2.1	4.75	0.46	1	Good
2.2	4.6	0.81	2	Good
2.3	4.5	0.83	3	Good
2.4	4.4	1.80	5	Fair
2.5	4.3	No floc		None
		February 25		
2.2	5.1	No floc		None
2.3	4.9	0.4	1	Good
2.4	4.9	0.91	4	Good
2.5	4.7	0.6	2	Good
2.6	4.6	0.93	5	Good
2.7	4.5	0.73	3	Good
2.8	4.4	0.93	6	Good

Summary of flocculation scores of 1 per cent solution, using a volume of 500 cc.

pH	4.4	4.5	4.6	4.7	4.8	4.9
Average score	5.0	3.0	2.8	1.6	2.0	3.5

1 per cent solution, volume 2500 cc.

ACID	pH	TIME OF FLOC	SCORE	SEDIMENTATION OVERNIGHT
		February 21		
cc.		minutes		
12.0	5.2	No floc		None
13.0	5.0	2.0	4	Good
13.5	4.9	1.0	3	Good
14.0	4.8	0.5	1	Good
14.5	4.6	0.6	2	Good
15.5	4.6	0.5	2	Good
16.0	4.4	59.0	5	Poor
		February 25		
12.0	5.2	Overnight	6	Good
12.5	4.9	0.93	4	Good
13.0	4.8	0.6	3	Good
13 5	4.7	0.6	2	Good
14.0	4.6	0.33	1	Good
14.5	4.5	2.0	5	Fair
15.0	4.4	No floc		None
15.5	4.3	No floc		None

Summary of flocculation scores of 1 per cent solution, using a volume of 2500 cc.

pH	4.4	4.5	4.6	4.7	4.8	4.9	5.0
Average score	5.0	5.0	1.5	2.0	3.0	2.6	4.0

Summary of all flocculation scores

pH	4.4	4.5	4.6	4.65	4.7	4.8	4.9	5.0	5.1	5.2
Average score	4.2	3.5	2.7	2.1	2.05	2.4	3.03	2.7	3.0	4.1

These results show that the precipitation of casein from dairy wastes is very satisfactory within the pH limits of 4.9 and 4.5. Since flocculation and sedimentation occur through this comparatively wide range of pH values the use of sulphuric acid should prove practicable in plant work.

The method to be used in disposing of the waste from a plant would be as follows: A water-proof tank should be constructed having a capacity somewhat greater than the volume of wash water and other waste which leave the plant daily. While the plant is in operation the combined waste should be delivered into this tank where it is mixed with sulphuric acid in such amount as will produce a red color with methyl red and a deep purple with brom-phenol blue, when small portions are withdrawn and

tested with those indicators. This will keep the pH within the limits of 4.6 and 4.8, or, at the outside, of 4.4 and 5.0. With a very little experience a plant operator of ordinary intelligence should be able accurately to adjust the pH of the waste and acid mixture to the desired value of 4.7. Agitation of some sort would be necessary for a short time to insure complete mixing of the acid and waste. The treated waste is now allowed to remain in the tank overnight when, except for the surface scum, almost complete sedimentation will have occurred.[3] An outlet should be provided for the tank at a sufficient height from the bottom that the supernatant liquid may flow off without disturbing the sediment. The outlet should have a check valve which would prevent lowering the surface of the liquid to that position where the surface scum could flow off. This supernatant liquid could then enter the stream or ditch without causing any considerable nuisance, as is shown by a study of the Relative Stability Values of the raw and treated waste.

Temperature does not affect flocculation or sedimentation, for satisfactory effluents were obtained from samples held at summer temperatures as well as from those which had frozen.

The length of time such a tank could operate without being cleaned would depend upon the concentration of the waste and the temperature. An accumulation of sediment from 1 per cent solutions was held in the laboratory at approximately 23° for eight days and then developed a slight odor. So it is believed that a weekly cleaning and disinfecting of the tank would be satisfactory for the greater part of the year. However during July and August undoubtedly a more frequent cleansing would be necessary, say, either two or three times a week. The ultimate disposal of the casein could be managed in any one of several ways: such as rapid drying and burning; plowing under the soil, or, perhaps, feeding to hogs. However, this last suggestion should be passed upon by an authority on hogs, before being tried.

From the results of the laboratory experiments it can be seen that different amounts of acid were required to produce the same

[3] In a few cases which were observed after standing seven hours, sedimentation was good, indicating that a shorter detention period might be satisfactory.

pH value. This is attributed to the difference in buffer strengths of the various milks used, for the tap water used for all dilutions showed a fairly constant pH value and buffer strength. In plant operation the wash water would always come from the same source and therefore it could be expected to have a farily constant pH value and buffer strength. It is probable that the milk, coming from the same sources would also be more uniform in composition than the different samples which were used in these experiments. Therefore it is anticipated that the amount of acid required to produce pH 4.7 in a known volume of waste could be rather accurately estimated.

Figuring that the volume of waste from a small plant would be 1000 gallons per day, if commercial sulphuric acid of 50° to 60° Baumé were used it would require about 1 pound of acid per day at a cost of from 3 to 5 cents to precipitate the casein.

An attempt was made to study the biochemical oxygen demand of the raw waste, designated as influent, and of the supernatant liquid resulting from precipitation of casein and overnight sedimentation, designated hereafter as effluent. The method used consisted of a determination of the dissolved oxygen present in the sample before and after a period of five days' incubation,—the difference between these two results being the oxygen used by the sample.

In Public Health Bulletin No. 97, 1918, by E. J. Theriault and H. B. Hommon, very exact directions for the application of this method are given. This technic was followed closely, but concordant results with various dilutions could not be obtained. After several unsuccessful attempts, which consumed much time, this method of comparing the influent and effluent was abandoned.

The relative stability of the influent and effluent was studied, using the method given in "Standard Methods of Water Analysis" American Public Health Association(9). "The time required to exhaust the available oxygen in a sample, as indicated by the decolorization of methylene blue at the incidence of putrescence, is a measure of the relative stability." The influent was allowed to stand overnight before incubating so that it would at all times be subjected to the same conditions as the effluent. The temperature of incubation was 20° + or −2°.

In the following table, "volume" = volume of milk solution treated; "per cent" = its percentage concentration; "R.S.I." = relative stability of the influent; "R.S.E." = relative stability of the effluent, and "pH" = hydrogen ion concentration of the effluent.

VOLUME	PER CENT	R.S.I.	R.S.E.	pH
		February 6		
500	0.50	16	80	4.5
			82	4.7
			82	4.8
			82	5.05
		February 8		
500	0.50	21	60	4.6
			70	4.7
			84	4.7
2500	0.50	21	64	4.95
500	0.25	21	70	4.85
2500	0.25	21	84	4.75
			84	4.65
			84	4.5
			84	4.45
		February 12		
500	0.50	14	60	5.1
			84	4.9
			99	4.6
			99	4.4
500	0.25	14	60	5.2
			84	5.0
			88	4.8
2500	0.25	14	95	4.8
			95	4.7
			95	4.6
			95	4.4
			94	4.3
		February 16		
2500	0.25	21	80	4.3
			95	4.35
			95	4.4
			95	4.6
			95	4.7
			95	4.8
			60	5.0

VOLUME	PER CENT	R.S.I.	R.S.E.	pH
		February 19		
2500	0.25	30	80	5.0
			97	4.9
			99+	4.8
			92	4.7
			99+	4.6
			99+	4.6
			98	4.6
			99+	4.5
			99+	4.3
500	1.0	16	60	5.0
			60	4.9
			99+	4.7
			98	4.6
			99+	4.6
			97	4.6
		February 21		
500	1.0	16	64	4.9
			94	4.75
			80	4.6
			99	4.5
			97	4.4
2500	1.0	16	64	5.0
			68	4.9
			80	4.8
			80	4.6
2500	0.25	16	95	5.0
			97	4.9
			99	4.7
		February 26		
500	1.0	16	37	4.9
			40	4.9
			68	4.7
			68	4.6
			97	4.5
			98	4.4
2500	1.0	16	16	5.2
			37	4.9
			44	4.8
			60	4.7
			96	4.6
			98	4.5

SUMMARY

1. Flocculation and sedimentation of the casein in milk wastes is good within the pH limits of 4.5 and 4.9.

2. The supernatant liquid resulting from waste so treated has a high relative stability number.

3. After detaining the treated waste in tanks until good sedimentation has occurred, the supernatant liquid can be discharged into a small stream or ditch without causing a nuisance.

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CLARIFICATION OF MILK FOR CHEESE MAKING[1]

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The clarification of milk has been a common practice in the modern milk plant for a number of years. Recently its application has been advocated in connection with milk to be used in the manufacture of cheddar cheese. The latest report found upon the subject is that given by Fisk and Price (1). These investigators summarize their findings as follows:

> There were 82 cheese made and 150 scorings. The average of the scores shows that the clarified-milk cheese scored 44.948 in flavor and the unclarified 43.666. In body and texture the clarified milk cheese scored 23.858 and the unclarified 23.185. The averages of the total scores were 93.773 for the clarified milk cheese, and 91.908 for the unclarified milk of both good and poor quality was used, and clarification of the milk seemed to improve the quality of the cheese from either. Starter was used in some tests and not in others, showing that clarification improves the cheese whether or not starter is used. The clarifier will sometimes overcome the gas in milk and curd; at other times it will not overcome this gas, but will change it.

Their results indicate an average improvement in the total score of cheese made from clarified milk of 1.865 as compared with cheese made from unclarified milk.

Manufacturing about 400 pounds of cheddar cheese daily, from milk of a poor quality, the Pennsylvania State College Creamery offered an excellent opportunity to study this problem. Work on clarification of this milk as a means of improving the quality of the cheese was started in December, 1922, and was completed in May, 1924.

[1] The data presented in this paper form a part of the thesis of N. A. Hugglar submitted in partial fulfillment of the requirements for the degree of Master of Science at the Pennsylvania State College.

This work was conducted on poor quality and milk of a high quality. The poor quality milk was the milk regularly delivered by the creamery patrons and the high grade milk used was produced by the College Dairy producing milk under certified requirements. It was placed in a large cheese vat thoroughly mixed and a portion removed for clarification. Cheddar cheese was then made from the clarified and unclarified milk. It was placed in the curing rooms for six to eight weeks, then removed and scored by three judges.

An attempt was made to learn if the care given utensils in connection with clarification would bear any relation to the resulting cheese. Milk received by the College Creamery was cared for under the ordinary conditions practiced in the creamery and a series of cheese made under these conditions. Following this experiment a series of cheese were made from the same grade of milk, but extreme care was taken in connection with cleansing all utensils and vats with which the milk came in contact. The vats were sterilized by filling them with boiling water for eight to ten hours before using, also the clarifier parts, the cans and the buckets were carefully sterilized.

CLARIFICATION OF POOR QUALITY MILK FOR CHEESE MAKING

This experiment was divided into two parts. In part 1 milk of a poor quality was handled under ordinary conditions after reaching the creamery. Conditions were not bad but no extreme precautions were made. In part 2 after the milk reached the creamery it was handled with extreme care, all utensils and equipment were sterilized before using. In each part the milk was divided into two portions one half was clarified, the other was not, then both were made into cheese. The results of this experiment are tabulated in table 1.

The results as shown in table 1 do not indicate any improvement in the cheese made from milk of a poor quality handled under practical conditions. However, with extreme care there was an improvement of 1.59 points in total score in favor of clarification. The cheese made from unclarified milk handled under ordinary

conditions had an average score of 86.01 while that made from the same grade of milk and clarified had an average score of 85.22.

It was frequently observed that there was less gas in the clarified milk than in the unclarified milk.

Figure 1 illustrates the only extreme case of gas reduction due to clarification in the manufacture of 82 cheese.

TABLE 1

Quality of cheese manufactured from clarified and unclarified milk of a poor quality, under ordinary and under very sanitary conditions

TRIAL NUMBER	SCORE OF CHEESE UNDER DIFFERENT METHODS OF HANDLING MILK			
	Ordinary		Very sanitary	
	Unclarified	Clarified	Unclarified	Clarified
1	80.0	77.0	84.0	84.0
2	90.0	89.0	86.33	98.5
3	88.0	87.0	88.66	90.0
4	86.0	86.0	84.0	89.66
5	85.16	83.4	80.83	87.5
6	87.0	85.5	92.0	87.0
7	82.75	87.33	83.0	83.0
8	88.5	83.8		
9	88.0	88.5		
10	89.0	87.7		
11	86.5	85.75		
12	82.5	81.75		
Average.....	86.01	85.22	85.55	87.14

CLARIFICATION OF A HIGH GRADE MILK FOR CHEESE MAKING

The first experiment was repeated in every detail with the exception of the grade of milk used in the manufacture of the cheese. The results are tabulated in table 2.

The results shown in table 2 clearly indicate that the cheese made under ordinary methods show an improvement of 2.1 points due to clarification while that made under sanitary conditions indicate an improvement of 2.87 points.

The average flavor score of cheese made from the clarified milk handled under practical conditions shows an improvement of 1 point over the unclarified milk and 1.16 points improvement on body and texture. Where the milk was handled under

extreme sanitary conditions the improvement due to clarification was 0.83 point in flavor and 1.66 points in body and texture. Figure 2 illustrates a representative group of the cheese made in this experiment.

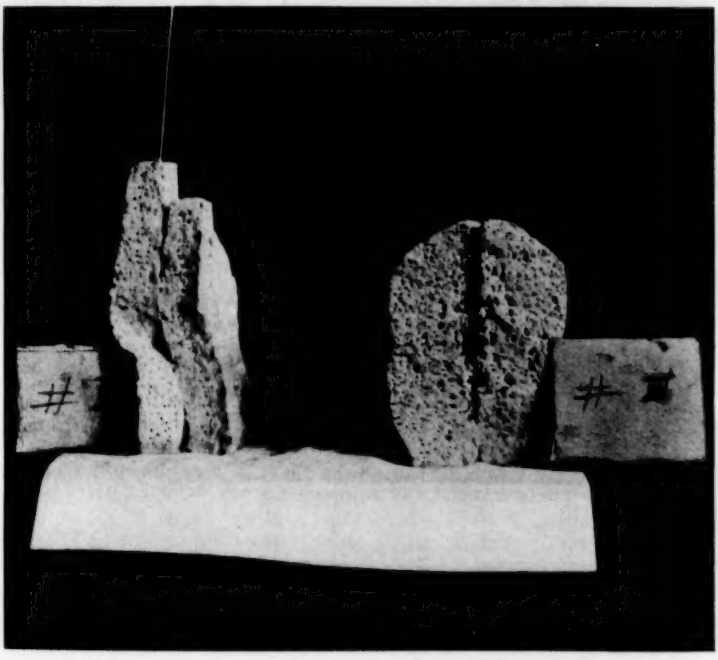

FIG. 1. (1) CURD PRODUCED FROM CLARIFIED MILK; (2) CURD PRODUCED FROM UNCLARIFIED MILK

The average total score of 82 cheese shows an improvement of 1.03 in favor of the clarified cheese. The score for the cheese was as follows:

41 clarified	87.58
41 unclarified	86.55

Under present market conditions the above cheese would sell for the same price. It would therefore be doubtful, whether the process of clarification can be justified in the average cheese factory.

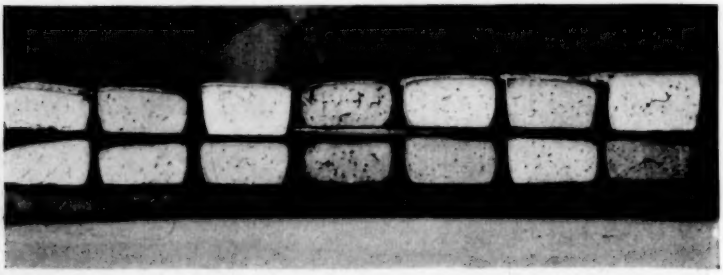

FIG. 2. A REPRESENTATIVE GROUP OF CHEESE MANUFACTURE IN EXPERIMENT 2 FROM CLARIFIED AND UNCLARIFIED MILK

Top row, unclarified; bottom row, clarified

TABLE 2

Quality of cheese manufactured from a high grade of milk clarified and unclarified and handled under ordinary and under very sanitary conditions

TRIAL NUMBER	SCORE OF CHEESE UNDER DIFFERENT METHODS OF HANDLING MILK							
	Unclarified				Clarified			
	Flavor	Body	Color	Total	Flavor	Body	Color	Total
				Ordinary				
1	25.0	32.0	8.0	85.0	25.0	35.0	8.0	88.0
2	24.0	34.0	8.0	86.0	24.0	35.0	9.0	88.0
3	22.0	32.0	9.0	82.0	24.0	35.0	8.0	87.0
4	20.0	32.0	9.0	81.0	24.0	35.0	9.0	88.0
5	26.0	35.0	9.0	90.0	24.0	33.0	9.0	86.0
6	24.0	33.0	8.0	85.0	26.0	32.0	9.0	87.0
Average..	23.5	33.0	8.33	84.8	24.5	34.16	8.67	87.33
				Very sanitary				
1	24.66	34.0	9.33	88.0	26.33	36.0	10.0	92 33
2	24.66	31.33	9.0	85.0	26.66	36.33	10.0	93.0
3	23.66	31.33	9.33	84.33	23.33	31.33	9.0	83.66
4	24.0	33.0	9.0	86.0	24.0	32.66	9.0	85.66
5								
6								
Average..	24.5	32.42	9.16	85.83	25.08	34.08	9.5	88.66

SUMMARY

A total of 82 cheese were made in this experiment. Clarification of a poor quality of milk under ordinary conditions showed no improvement in the score of cheese.

Clarification of poor quality milk handled under strictly sanitary conditions resulted in an improvement of 1.59 points in the score of the cheese.

Clarification of a high quality milk under ordinary conditions resulted in an improvement of 2.53 points.

Clarification of a high quality milk under strictly sanitary conditions resulted in an improvement of 2.83 points in the total score of the cheese.

On the average clarification resulted in an improvement of 1.03 points in total score.

The writers wish to express their thanks to C. W. Fryhofer formerly of the United States Department of Agriculture, Dairy Division, for his assistance in scoring a number of the cheese used in this experiment.

REFERENCE

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REVIEW OF FOREIGN DAIRY LITERATURE

H. A. BENDIXEN

University of Idaho, Moscow, Idaho

REISS, VALBERG. *Use of saltpeter in cheese making.* (Milchwirtschaftl. Zentrabl. 1922. 51. Jahrg. H. 6. S. 68–69.)

The action of saltpeter probably consists in giving up its soluble acid to bacteria that need it for their development, while otherwise they would have to attack the milk sugar and other ingredients whereby compounds and gases detrimental to the taste of the cheese may result. The amount of saltpeter must be regulated according to the quality of milk, kind of cheese, acidity, storage and later holding temperature no matter if we deal with pasteurized or raw milk. Experience there is of great importance. Too large amounts hurt the cheese, because it forms in that case a flaming red colored mass with an unclean taste and the ripening period is prolonged. If fermenting feeds or green feed of vetch, alfalfa, etc., are used saltpeter may be used up to 30 to 60 grams per 100 kgm. of milk. More may be used for Gouda, Edam and home made cheese types than for higher acid, much stirred cheese (cheddar, pastor) or for late warmed (large holed cheeses) or for pasteurized milk cheese or for types of cheeses in which cultures of rod shaped lactic acid bacteria are used (Swiss). Since the latter retard the fermentations in the cheese by the acid formed and thus act in this direction like saltpeter this amount must be decreased in the same ratio as the amount of pure culture is increased. In pasteurization of cheese milk the bacteria causing a gassy fermentation are partly killed and such milk requires only half as much saltpeter as unpasteurized milk. With a low storage temperature less saltpeter is used than with a high one. The use of saltpeter makes storage at a higher temperature possible whereby curing is hastened without injury to the cheese. Saltpeter must be added to the milk with thorough stirring before setting. If a 2-liter solution contains 1 kg. saltpeter, then use twice as many cc. as the grams of saltpeter that are desired. The saltpeter should be dissolved in warm water and filtered; KNO_3 or $NaNO_3$ may be used. Matouschek (Vienna).

MUELLER, A. *Experimentation keeping milk sweet by adding small amounts of hydrogen peroxide.* (Milchwirtsch. Zentralbl. Jahr. 51. 1922. S 25–29, 37–39, 49–53, 61–64.)

The bactericidal action of H_2O_2 is due to the undecomposed H_2O_2 itself and not the O which is freed during the breaking up by catalase. Catalase actions must therefore be disregarded in the addition of this medium. The author conducted experiments to ascertain whether it is possible to keep milk fresh without changing the taste of the milk by adding H_2O_2 after inactivating the catalase by heat. The milk came from a cow stable in Berlin-Friedenau. To inactivate the catalase heating to 70 to 71° for one-half hour was practiced; then cooling to the experimental temperature, making the H_2O_2 additions, filling into not sterile Erlenmeyer flasks and holding in the dark. The milk kept with the addition of 0.1 to 0.15 per cent H_2O_2 three and four times as long as milk which was just pasteurized one-half hour at 70°C. At first the taste of the milk was somewhat affected, later not at all. The same milk without H_2O_2 spoiled regularly in twenty-four to forty-eight hours. Also milk which was exposed to air contamination in cooling kept with the given amount of H_2O_2 added at least twenty-four hours longer than the H_2O_2 free control milk. In dairies good results will be obtained, if the air contamination is avoided during cooling by using a light protective guard around the cooler and if the splitting of the H_2O_2 by catalase caused by rust is avoided by using well tinned cans. Matouschek (Vienna).

MAZZEO, MARIO. *On the mechanism of the coagulation of milk produced by bacteria.* (Pathologica An., 14, 1922, p 162–171.)

In the experiments the dependence of the force and speed of the coagulation of milk upon the acid content of the milk came to light. Bac. bifidus alone acts through acid formation. Enterococcus and also Pneumococcus act thus and also by means of a coagulating enzyme.

Rona, P., and Gabbe, E. On the influence of calcium on the rennet coagulation of milk (Biochem. Ztschr., vol. 134, 1922, p. 39).

The authors came to the following conclusions:

1. The action of calcium on the rennet coagulation of milk was studied by adding calcium chloride to the ten to thirty times diluted and with rennet mixed milk during different stages of the enzyme activity and by noting the time until the beginning of coagulation. The hydrogen ion concentration of the milk was regulated by means of acetate buffer.

2. The progress of the enzyme action was analyzed by determining the temperature at which the milk at the different stages may be caused to coagulate. Considering the Ca-content, degree of dilution and pH value the temperature of coagulation proved to be characteristic and determinable with sufficient accuracy for a certain stage during the change of the casein into paracasein by the enzyme.

3. By means of the coagulation temperature of mixtures of coagulating and rennet-free milk it is possible to replace the coagulation temperatures determined in the course of a certain coagulation experiment by conversion figures which show how much of the existing casein was changed into paracasein by the enzyme.

4. If the calcium chloride is added at the beginning of the enzyme action the time until the beginning of coagulation is longer the higher the calcium content of the solution is. The experiments to analyze the enzyme action show that low calcium concentrations favor the enzyme action, while the higher ones retard it.

5. If the calcium chloride is not added until during the enzyme action then a prolongation of the time required for coagulation is regularly noticed, which varies with the time of adding the calcium and the calcium concentration. This prolongation of the time of coagulation occurs also with such $CaCl_2$ concentrations which when added at the beginning of the enzyme action hasten the action. This action of the calcium when added later may be explained by a retardation of the enzyme action and by changes in the precipitability of the paracasein by the calcium.

6. The change of the casein into paracasein is complete only at a pH value of 6.0 to 6.4 which is the optimum for precipitation of the paracasein calcium. At a higher hydrogen ion concentration coagulation takes place while the casein change is incomplete. Heuss (Berlin).

STOKOE, U. *Rancidity of butter and margarine.* (Chem. Umschau, Bd. 28, 1921, S. 132.)

The rancidity of water-free fats is not due to the activity of microorganisms; the author inoculated several fats and oils with a culture from rancid margarine and after two weeks found only a very slight increase in the free fatty acid and no changes in odor and taste. The rancidity of margarine falls into three groups:

1. Tallowy odor and taste, no change in color, caused by an oxidation process in which glycerin already split off is oxidized to glycollic acid.

2. Aromatic odor, disagreeable taste, only in margarine made from cocoanut oil or palm kernel oil. Penicillium glaucum produces the odoriferous substances.

3. Slight changes in odor and taste; Aspergillus produces gray or bluish black coloring, Bacillus prodigiosus red coloring. Many oils and fats of commerce are filled with molds and other spore forming organisms. Therefore it is necessary to examine these carefully and to keep them pure.

American Dairy Science Association Meets at Milwaukee

The Wisconsin hotel will be headquarters for the A. D. S. A. at Milwaukee. Write E. A. Rolph, manager of the hotel, for reservations, mentioning the fact that you are a member of the association.

All the meetings of the American Dairy Science Association will be held in the Milwaukee auditorium on Monday, September 29, 1924. The general session starting at 9:00 a.m. followed by the meetings of the production, manufacturing, and extension sections at 1:30 p.m., and the advanced registry section at 7:30 p.m.

The general session of the American Dairy Science Association will be addressed by E. D. Ball, in charge of the Scientific department of the U. S. Department of Agriculture, by L. A. Rogers of the dairy bureau and by the Editor of the Journal of Dairy Science, Dean H. L. Russell and Chief Larson will be the speakers at the banquet. The program of the Production section is as follows:

1:30 P.M., SEPTEMBER 29, 1924

Call to order by Chairman.....J. J. Hooper
Reading of minutes of last meeting, Secretary.....J. A. Gamble
Address: "Twenty Years of Progress in Animal Nutrition"
Dr. E. B. Hart
Report of Committee on National Students Judging Contest
W. W. Swett, *Chairman*
Report of Southern Contest.....J. J. Hooper, *Chairman*
Address: "Some Observations on the Relation of Conformation to Production in Dairy Cattle".....R. R. Graves

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The program of the other sections will be available later